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ABSTRACT

This document reports on the state of employment among individuals holding doctoral degrees in science and engineering. Definition of key terms, an executive summary, discussion of trends in doctoral science and engineering unemployment, examination of factors affecting unemployment in 1993, an exploration of changes in factors affecting unemployment since 1973, and a discussion of implications for future research are included. The appendices contain further information on unemployment, involuntary part-time employment, and involuntary out-of-field rates for selected subgroups within the doctoral science and engineering population in 1993; variables excluded from multivariate analysis; variables eliminated during the multivariate analysis for lack of statistical significance; other variables in the final model not discussed in the body of the report; and technical notes. Contains 22 references. (DDR)

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Who Is Unemployed? Factors Affecting Unemployment Among Individuals with Doctoral Degrees in Science and Engineering

An SRS Special Report

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Who Is Unemployed? Factors Affecting Unemployment Among Individuals with Doctoral Degrees in Science and Engineering

An SRS Special Report

Carolyn F. Shettle, Principal Author

Division of Science Resources Studies
Directorate for Social, Behavioral and Economic Sciences

National Science Foundation

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KEY TERMS

Unemployed: Either on layoff or not employed but searching for work (during the four-week period prior to the reference date). NOTE: Individuals who are not working and not employed are defined as being out of the labor force. This group includes most individuals who are voluntarily not employed.

Labor Force: The labor force consists of unemployed plus employed individuals.

Unemployment Rate: The percent of the labor force that is unemployed.

Standardized Unemployment Rates: A number of techniques can be used to estimate the effect of one (independent) variable on another (dependent) variable, while "controlling" for other variables. The most straightforward technique is to construct a three-way table. For example, the average age of women in the doctoral labor force is less than that of men. To determine whether age and/or gender are related to the unemployment rate, it is logical to look at unemployment rates within sex-age groups (for example, men under age 30 compared with women under age 30, men aged 31–35 compared with women aged 31–35, etc.). Although cross-tabulations can be extremely helpful in understanding how two or more independent variables affect a single dependent variable, usefulness is limited by the fairly large sample sizes needed to estimate accurately subgroup unemployment rates. This becomes an especially serious problem when controlling for more than one variable. (For example, to understand whether observed differences in unemployment rates for individuals with disabilities can be explained by the fact that individuals with disabilities tend to be older than individuals without disabilities, and the fact that the incidence of disabilities tends to be higher among men than among women).

Instead of using cross-tabulations for control purposes in this report, a multivariate technique known as logistic regression analysis was used to estimate the simultaneous effect of a large number of variables on unemployment. The independent variables used in the logistic regression model are: degree field; place of employment or residence; years since receipt of Ph.D.; age when doctorate received; years of part-time experience; years of full-time experience; whether or not employed in April 1988; occupation in April 1988 (for employed individuals); employment sector in April 1988 (for employed individuals); parents' level of education; disability status; percent involuntarily out-of-field in the 1988 occupation; foreign research experience; marital status; interaction between gender and marital status; interaction between gender and whether children are in the home; interaction between gender and race/ethnicity; and interaction between marital status and race/ethnicity.

The logistic regression model was used to estimate the unemployment rate for a group of individuals who exhibited the same values on all of the independent variables except the one under consideration. For example, the observed unemployment rate for individuals with hearing disabilities was 3.0 percent, compared with a rate of 1.6 percent for non-disabled doctoral scientists and engineers; the respective standardized rates were 2.5 percent and 1.6 percent. Thus, factors listed above (other than whether the person had a hearing disability) explained some but not all of the observed difference between those with hearing disabilities and those without disabilities.

More detailed information about the standardization process is included in the Technical Notes. (See p. 49.)

EXECUTIVE SUMMARY

The primary purpose of this report is to explore empirically the factors affecting unemployment[1] among individuals with U.S. doctoral degrees in science and engineering in 1993. This information is of interest to individuals who are in—or considering entering—science and engineering, their advisors, and those responsible for programs serving them. The major questions addressed are:

How high were unemployment rates for doctoral scientists and engineers in the early 1990s?

- The 1993 unemployment rate of 1.6 percent was the highest rate observed in the biennial Survey of Doctorate Recipients (SDR) between 1973 and 1995. However, the April 1993 unemployment rate for those with science and engineering doctorates was substantially below the total population rate of 7.1 percent. The 1995 doctoral unemployment rate of 1.5 percent was virtually unchanged from the 1993 rate, even though the unemployment rate in the total labor force declined considerably to 5.7 percent.

How well can we predict unemployment rates in the doctoral science and engineering population?

- According to evaluations of past forecasts of the doctoral science and engineering job market, it is not now possible—and may never be possible—to forecast doctoral science and engineering unemployment rates with sufficient accuracy to be helpful in deciding whether or not to pursue doctoral-level careers in science and engineering, particularly in view of the long lead-time for obtaining this degree.

If we can't predict unemployment rates, why is it worth asking who is unemployed?

- Even though it is not possible to predict total doctoral science and engineering unemployment rates, generalizations can be made about unemployment in this population. For example, in the mid-1980s, an examination of doctoral science and engineering unemployment trends would probably not have led to an accurate prediction of the 1995 unemployment rate, but could have correctly predicted that doctoral scientists and engineers would continue to experience unemployment rates below those of the general population. It is reasonable to hypothesize that there is also some stability in the relative levels of subgroup unemployment rates over time.

Within the doctoral science and engineering population in 1993, who was most likely to be unemployed?

- Neither gender nor race/ethnicity had a statistically significant relationship with unemployment, when the other variables in this analysis were taken into account. However, having a hearing or mobility impairment or advanced age were associated with relatively high unemployment.

- Marital status and having children in the home have different effects on the unemployment status of the two sexes. For women, being married and having children were associated with relatively high unemployment rates; for men they were associated with relatively low unemployment rates.

- Education-related decisions are important predictors of unemployment:

  - Age at completing the doctorate is strongly associated with unemployment. When controlling for other relevant variables, the unemployment rate ranged from 0.6 percent for those who received doctorates before age 26 to 5.8 percent for those who received doctorates at age 40 or older.

  - Degree field is also important. In 1993, unemployment rates ranged from 0.6 percent for those with degrees in civil engineering to 2.5 percent for those with degrees in the geological and environmental sciences.

- Disruptions in full-time employment subsequent to receiving a doctorate increase significantly the chances of unemployment:

[1] The definition of unemployment used in this report is the standard Federal definition of not being employed and either being on lay-off or having sought work within the preceding four weeks. Individuals who are voluntarily without employment due to retirement, illness, family responsibilities, etc. are considered to be out of the labor force.

- Among those who were either unemployed or not in the labor force in 1988, the 1993 unemployment rate was 4.1 percent, compared to 1.5 percent for those who were employed in April 1988. The 1993 unemployment rate for those who had completed their doctorates before 1988, but were not employed in that year, was 9.6 percent—the highest unemployment rate observed in the study.

- Unemployment decreases with the number of years of previous full-time employment, when other variables are controlled for. However, prior part-time employment is associated with above-average unemployment rates.

- Other career-related variables found to be related to unemployment in 1993 were:

  - Among those employed in 1988, employment in the private-for-profit sector was associated with relatively high 1993 unemployment (2.6 percent). In contrast, prior employment in academia or the government was associated with low unemployment rates.

  - Occupation in 1988 was also a factor in predicting 1993 unemployment. The observed rates ranged from under 0.4 percent for postsecondary teachers in the physical sciences and engineering in 1988 to 2.9 percent for chemists (excluding postsecondary teachers). In general, those employed as postsecondary teachers in 1988 had lower unemployment rates than individuals in allied fields who were not postsecondary teachers.

  - Geographic location had a modest association with unemployment in the doctoral science and engineering population. Unemployment rates ranged from 0.3 percent in less populated states in the West North Central region (Iowa, North Dakota, South Dakota, Nebraska, and Kansas) to 2.8 percent in California in 1993. This association remained even after controlling for other relevant variables.

Have the factors affecting unemployment changed over time?

- There was a notable change between 1973 and 1993 in the association between gender and unemployment. In 1973, unemployment for men was 0.9 percent versus 3.9 percent for women; in 1993, the rates were 1.6 and 1.8 percent, respectively. This mirrors a similar decrease in the gender unemployment gap in the general population.

- Being an older member of the labor force is more strongly associated with unemployment in 1993 than in 1973.

- Although field of degree has a modest relationship with unemployment in both 1973 and 1993, there is little consistency between the two years on fields with the highest unemployment rates. This is consistent with traditional economic theory that indicates markets tend toward equilibrium over time. For example, when demand for a particular skill is high, compensation for the skill increases, which, in turn, encourages more individuals to acquire the scarce skill, thereby reducing or eliminating the scarcity.

- For the other two career-related decisions examined (sector and place of employment/ résidence), there was little difference between 1973 and 1993 in either the strength of the associations or the pattern of the unemployment rates.

How well does the unemployment rate perform as an indicator of career outcomes compared to other possible indicators?

- The unemployment rate is viewed by economists as an indicator of the health of the economy. However, from the individual's perspective, unemployment is only one of several possible desirable or undesirable career outcomes, resulting from a combination of job opportunities, individual choices, and luck. For example, when individuals are unable to find suitable full-time employment, they may decide to search for employment that is part-time and/or inconsistent with the level or field of their training. Because individual choices and job opportunities are themselves a function of many of the factors examined in this report, it is not surprising that the association between unemployment and the alternate measures of labor market stress (involuntary part-time employment and involuntary out-of-field employment) is weak.

I. Introduction

Who is unemployed among those with doctoral degrees in science and engineering? This question is of interest to those who hold such degrees and those considering a doctorate in science and engineering. This information is also important to policy makers and administrators in the government, members of academia, and other individuals who are responsible for designing, implementing, and monitoring advanced education and career programs.

To provide relevant information, data from the 1993 Survey of Doctorate Recipients (SDR) for individuals under the age of 76 with doctoral degrees in science and engineering from U.S. universities were analyzed. These 1993 results were also compared with data reported for 1973 in two National Academy of Sciences reports, *Employment Status of Ph.D. Scientists and Engineers 1973 and 1975* and *Doctoral Scientists and Engineers in the United States, 1973 Profile*.

Limitations of This Study

Three important limitations of this study need to be highlighted:

- Unemployment represents only a single possible outcome of career decisions. For employed individuals, a variety of job characteristics are of interest—for example, the nature of the work to be done, the work setting, the time demands, and the salary, prestige, and challenge of the position. A doctorate in science and engineering is not pursued simply to avoid unemployment but to obtain certain types of employment. Thus, a study of the factors affecting unemployment is only one of a series of studies of interest to individuals with doctoral degrees in science and engineering and those considering such degrees.

- This study focuses on individuals under the age of 76 with doctoral degrees in science and engineering from U.S. institutions.[2] Individuals not in the labor force (those neither working, seeking work, nor on lay-off) are excluded from this analysis.[3] This narrow focus permits an understanding of a population likely to differ significantly from the general population and from other subgroups within the science and engineering population.

- The multivariate approach used in this report is, at best, an imperfect substitute for a carefully controlled experiment.[4] Determining that an association exists between unemployment and a particular variable does not prove that the variable caused the unemployment. Alternate explanations are that unemployment caused the variable (for example, unemployment may lead an individual to seek additional training) or that unemployment and the variable of interest are both caused by other factor(s) associated with both the variable and unemployment (for example, unemployment rate differences between two race/ethnic groups may be explained by age differences between the groups). Caution, therefore, must be exercised in interpreting the data.[5]

---

[2] See the Technical Notes for additional information on the survey.

[3] Limiting the population of interest to those who are in the labor force is consistent with the standard Federal definition of unemployment used by the Bureau of Labor Statistics.

[4] See Technical Notes for a more detailed discussion of the methodology used in this report.

[5] See Marini and Singer for a more detailed discussion of the relationship between statistical association and causality.

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II. Trends in Doctoral Science and Engineering Unemployment

Introduction

What have been the past trends in doctoral science and engineering unemployment? What are they likely to be in the future? These questions, frequently asked by planners and policy makers, are addressed in this section through a discussion of the trends between 1973 and 1995[6] and a brief discussion of past attempts to predict unemployment trends.

Past Trends

In 1993, the unemployment rate for the doctoral science and engineering population was 1.6 percent, somewhat higher than the 1973 rate of 1.2 percent[7] —a statistically significant difference.[8] In both years, the doctoral unemployment rates were less than a quarter of the national rates of 7.1 percent in April 1993[9] and 5.0 percent in April 1973.[10] The 1995 doctoral unemployment rate (1.5 percent) was virtually unchanged from the 1993 rate, even though the overall unemployment rate declined considerably (to 5.7 percent).

Although the overall doctoral unemployment rate in 1993 was much lower than the rate for the general population, it is important to note that the 1993 rate was the highest observed rate to date in the biennial SDR.[11] This is consistent with observations that unemployment in subgroups of the doctoral science and engineering population was unusually high in the early 1990s.[12]

The relatively low rate of unemployment in the doctoral science and engineering (S&E) population is also consistent with the fact that unemployment rates decrease as educational level rises in the general population. Three major observations can be made about the importance of education level by comparing SDR unemployment rates with total population unemployment rates by level of education between 1973 and 1995 (chart 1).

- During this period of time, education level and unemployment had a strong negative correlation. The trend line for the doctoral science and engineering population lies consistently below that for the college-educated population.
- The unemployment rates of the doctoral population fluctuated less than that of other educational groups. The ratio of maximum to minimum unemployment rates observed over this time was 1.8 for the doctoral population compared to 2.1 for the college population and approximately 3.0 for the populations with high school or lower levels of education.
- There is no apparent association between unemployment rates in the doctoral science and engineering population and those in the total population ($r = -.08$).[13] Thus, predictions of future unemployment rates in the economy as a whole are not relevant for the population of doctoral scientists and engineers.

The observed relationship between degree level and unemployment rate is consistent with the findings of the 1972 National Science Foundation's (NSF) unemployment study, which reported data on scientists

[6] The trend data include 1995 SDR data that became available during final revisions of this report. It was not feasible to incorporate fully the new data into this report in a timely fashion. As noted in the concluding section, the new data will provide considerable opportunities for expanding the analyses in this report.

[7] Maxfield, Ahearn, and Spisak, p. 1.

[8] Throughout this report "statistically significant" is used to mean statistically significant at the .05 level. See the Technical Notes for specific information on how these tests were done.

[9] U.S. Department of Labor, p. 31. Note: this is based on non-institutionalized population aged 16 and over.

[10] Bureau of Labor Statistics (BLS), statistics on seasonally adjusted unemployment rates for the civilian population, aged 16 and over downloaded from the BLS Web site (http://stats.bls.gov/).

[11] National Science Foundation 1994, p. 8 and NSF 1991, p. 18. See the Technical Notes for a discussion of the likely impact of changes in methodology on the trends.

[12] See, for example, Greene, Hardy, and Smith, p. 59; Gruner, Langer, Nelson, and Vogel, p. 25; Magner, p. A19.

[13] For all other educational groups, the correlation between the group's unemployment rate and the total rate was positive and statistically significant.

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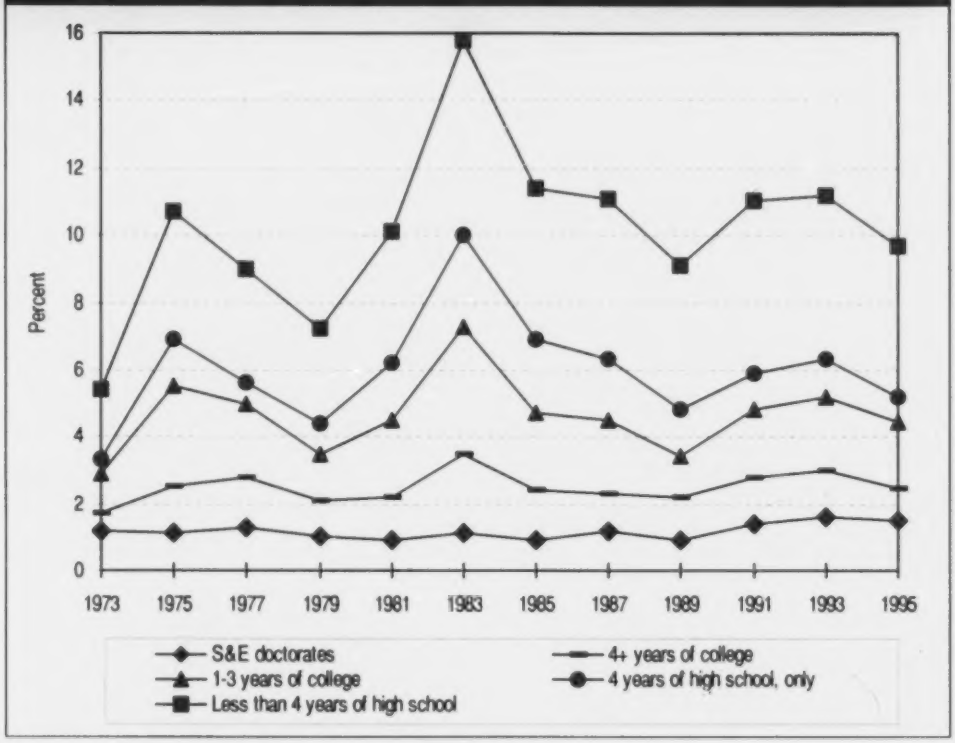
Chart 1. Unemployment rates of persons with doctoral degrees in science and engineering and persons 25 to 64 years of age in the overall population, by educational level: 1973–95



NOTE: Data for the doctorate population in 1991 and 1993 are not strictly comparable to each other or to those in preceding years.

SOURCES: Doctoral statistics from National Science Foundation/SRS, Survey of Doctorate Recipients. General population figures from Bureau of Labor Statistics, BLS, Current Population Survey.

and engineers separately. In that study, the unemployment rate for doctoral scientists was 1.4 percent compared with 3.7 percent for those holding master's degrees and 3.5 percent for those with bachelor's degrees. For engineers, the corresponding unemployment rates were 1.9 percent, 3.2 percent, and 2.8 percent, respectively.[14] Similarly, in 1993, the unemployment rate was 1.6 percent for those with a doctorate in science and engineering from a U.S. institution, 2.7 percent for those with a master's degree in science and engineering, and 4.0 percent for those with a bachelor's degree in science and engineering.[15]

Another view of the unemployment trends in the population of individuals with doctorates in science and engineering can be obtained by examining the ratio of unemployment in the overall U.S. labor force to that in the doctoral S&E labor force (chart 2). In both 1973 and 1995, the ratio of total unemployment to doctoral unemployment was relatively low, approximately 4:1. In the intermediate years, the ratio reached a maximum value of approximately 9:1 in 1983, the peak year of unemployment in the country.

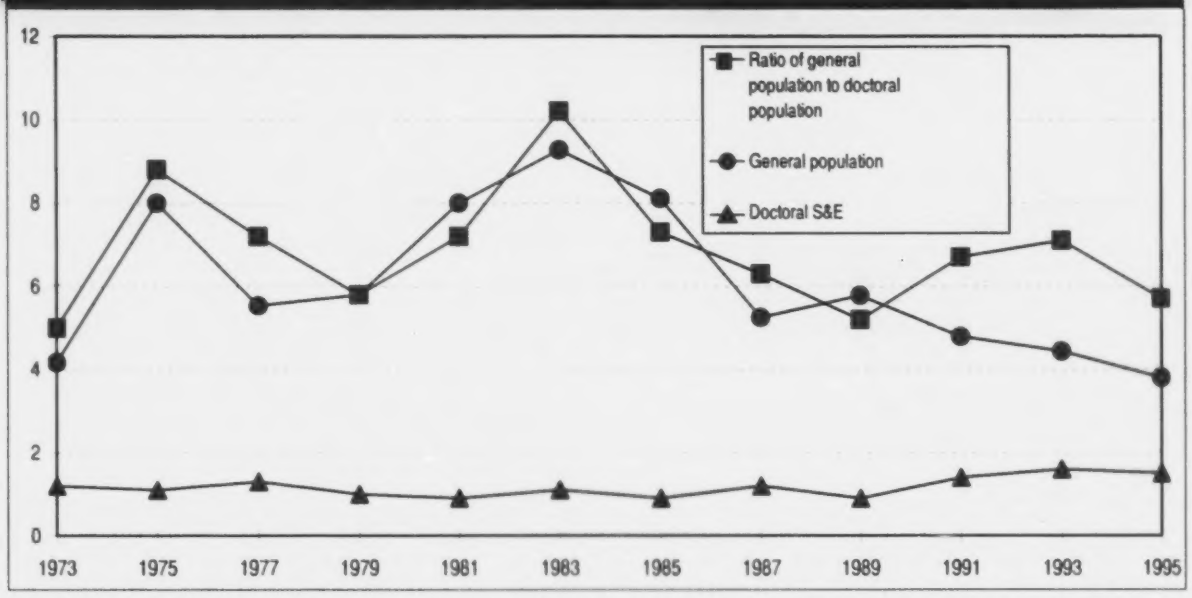
Future Trends

Predicting doctoral science and engineering unemployment requires specialized prediction models, because of the negligible association between unemployment in the doctoral science and engineering labor force and that in the general population. Although there

[14] NSF 1972, pp. 15 and 63.

[15] Data from special tabulations of the 1993 Science and Engineering Statistical (SESTAT) database that integrates data from the Survey of Doctorate Recipients with data from the National Survey of Recent College Graduates and the National Survey of College Graduates (http://www.nsf.gov/sbe/srs/stats.htm).

Chart 2. Ratio of April unemployment rates of U.S. civilian labor force 16 years and older to April unemployment rates for those with doctoral degrees in science and engineering: 1973–95



SOURCES: Doctoral statistics from National Science Foundation/SRS, Survey of Doctorate Recipients. General population figures from Bureau of Labor Statistics, Current Population Survey.

have been attempts to develop such models, the work is difficult and thus far has produced no evidence of success.

Relevant literature on this topic was summarized in the *Report of the Ad Hoc Working Group on the Supply of Science, Engineering, and Mathematics (SEM) Professionals* (1993). The report concluded, "It is not currently possible and will probably never be possible to predict with a high degree of accuracy shortages or surpluses of scientists and engineers several years into the future." A similar sentiment was echoed in a more recent publication (Tobias et al., p. 16), "Given the time lag in producing scientists,...it is particularly hard to predict, no less adjust, supply and demand."

Indeed, it can be argued that publicizing job market predictions results in the predictions becoming invalid. In other words, a prediction that a field will be "hot" several years from now increases the attractiveness of the field. This increases the supply of individuals capable of filling positions in the field, which, in turn, prevents the predicted shortage from materializing.

Conclusions

Past trends indicate that there is little, if any, association between doctoral science and engineering unemployment and unemployment in the general population. Attempts to develop specialized models to predict doctoral science and engineering unemployment have proven to be unsuccessful. Accurate predictions may never be feasible given that the predictions themselves are likely to alter the balance of supply and demand.

III. Factors Affecting Unemployment in 1993

Introduction

In this section data are examined to determine the relationship of demographic and career-related factors to unemployment in the doctoral science and engineering population.[16] The demographic variables examined include: sex; family status; race/ethnicity; place of birth; disability status; and age/time since completion of degree.

Several career-related variables that are at least partly under an individual's control are also examined in this section. Two of these variables—field of degree and age upon completing the doctoral degree—are related to educational choice. Three variables examined are measures of different aspects of prior work experience—years of full-time work experience, years of part-time work experience, and whether the individual was employed in April 1988. The final three variables pertain to other aspects of employment among those working in 1988—employment sector, location, and occupation.

Demographic Factors

Race/Ethnicity

According to a Department of Labor report, "Jobless rates among black workers have consistently been 2 to 2.5 times that for whites. Persons of Hispanic ethnicity have generally fared somewhat better than blacks, though they also experience higher rates of joblessness than whites."[17] The Department of Labor attributes this association between race/ethnicity and unemployment only partially to the lower educational levels of blacks and Hispanics.[18] However, among individuals with doctoral degrees in science and engineering fields, race/ethnicity does not appear to affect substantially the likelihood of being unemployed. The unemployment rate for non-Hispanic blacks in 1993 was 1.4 percent; for Hispanics of all races it was 1.9 percent, compared to the 1.6 percent rate for non-Hispanic whites. These differences were not statistically significant. The overall association between race/ethnicity and unemployment also was not statistically significant when controlling for the other variables in the analysis.[19]

Gender and Family Status

Gender

In 1993, women doctoral scientists and engineers had a slightly higher unemployment rate than men (1.8 percent compared to 1.6 percent), but the difference was not statistically significant.[20] A multivariate analysis confirmed the lack of a statistically significant relationship between gender and unemployment status in 1993, when other relevant factors were controlled.[21]

Family Status and Gender

In the general population, marriage and children are associated with low unemployment rates.[22] A similar pattern existed in the 1993 doctoral science and engineering population. However, the impact of marriage and children is quite different for men and women in the doctoral population.

Single men have a higher rate of unemployment than married men, but the same is not true for women (table 1). The unemployment rate for married men was 1.3 percent, compared to 2.8 percent for unmarried men. The comparable unemployment rates for women were 1.9 percent and 1.6 percent, respectively. Standardization did not change these relationships.

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[16] Information on some additional variables is included in the Technical Notes and Appendix Tables.

[17] U.S. Department of Labor, p. 33.

[18] *Idem.*

[19] While the main effect of race/ethnicity was not statistically significant, there were some statistically significant interaction effects noted. These are discussed in Appendix B.

[20] All tests of significance used in this report are approximate and calculated at the .05 level. See the Technical Notes for more information on these tests.

[21] After determining that the main effect of gender on unemployment was not significant, interaction effects between gender and family status variables were introduced into the model and found to be significant. The statistical techniques are discussed in the Technical Notes.

[22] In 1993, the unemployment rate for married men was 4.4 percent, compared to 7.1 percent for men in the total population. U.S. Department of Labor, p. 186. In 1980, married men had an unemployment rate of 4.2 percent, compared to a total unemployment rate for all men of 6.9 percent. For women, the comparable rates were 5.8 percent and 7.4 percent. Bureau of Labor Statistics, p. A-13.

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Table 1 Unemployment rates for doctoral scientists and engineers, by marital status and gender: 1993

Marital status/gender	Population Size	Actual Unemployment Rate	Standardized Unemployment Rate/1
		By Percent	
Married -- total	374,390	1.4 *	1.4
Men	311,980	1.3 *	1.3
Women	62,410	1.9	1.9
Not married -- total	96,110	2.4 *	2.4
Men	63,230	2.8 *	2.8
Women	32,880	1.6	1.6
All individuals	470,500	1.6	1.6

*Difference between unemployment rate observed in group and total unemployment rate excluding those in the group is statistically significant at .05 level.

/ See the Technical Notes for an explanation of the adjustment methodology used in calculating standardized unemployment rates.

NOTE: Detail may not add to total because of rounding.

SOURCE: National Science Foundation/SRS, 1993 Survey of Doctorate Recipients.

The unemployment rate for individuals with children in the home (1.4 percent) was lower than the unemployment rate for those without children living in the home (1.9 percent) (table 2). Like marital status, having children produced significant differences in the unemployment rates of men and women. Although women with children had unemployment rates exceeding those for women without children (2.4 percent compared with 1.2 percent), men with children had lower unemployment rates than their childless counterparts (1.2 percent compared with 2.1 percent). Standardization on the non-demographic variables did not reduce significantly the strength of this interaction effect.

In order to determine if the impact of family status on unemployment was different for men and women in the general population, unemployment rates by sex and family status were calculated from Bureau of Labor Statistics data for March 1996. In the general population, the unemployment rates for both married women and men were below those for unmarried individuals. However, the difference in unemployment rates was more dramatic for men than for women. The unemployment rate for unmarried men was 8.7 percent, compared to 3.6 percent for married men; the corresponding rates for women were 5.6 percent and 3.3 percent. As was true in the doctoral science and engineering population, the impact of children on unemployment within the general population was different for the two sexes. Men with children had relatively low unemployment rates compared with men without children (4.0 percent versus 5.5 percent); while for women, the unemployment rate for those with children was higher (4.5 percent compared to 3.8 percent).[23]

Place of Birth

Pre-college educational experiences, among others, are important in shaping values, interests, and job-related skills that continue throughout a career. Unfortunately, it is not easy to develop valid measures of such characteristics for use in a large-scale survey. Since educational and other childhood experiences are likely to be affected by place of birth, this variable can be used as a rough indicator of such experiences.

The association between place of birth and the unemployment rate was statistically significant in the 1993 doctoral science and engineering population; however, the association was not particularly strong

[23] These figures were calculated using Ferret, an online database from the March 1996 Current Population Survey (http://ferret.bls.census.gov/cgi-bin/ferret). Unemployment rates were calculated for individuals aged 25–75.

Table 2. Unemployment rates for doctoral scientists and engineers, by gender and whether there are children in the home: 1993

Children in Home/Gender	Population Size	Actual Unemployment Rate	Standardized Unemployment Rate[1]
		by Percent	
Children present -- total	252,700	1.4 *	1.6
Men	209,420	1.2 *	1.4
Women	43,280	2.4 *	2.6
Children not present -- total	217,800	1.9 *	1.8
Men	165,790	2.1 *	2.0
Women	52,010	1.2 *	1.2
All individuals	470,500	1.6	1.6

* Difference between unemployment rate observed in group and total unemployment rate excluding those in the group is statistically significant at .05 level.

[1] See the Technical Notes for an explanation of the adjustment methodology used in calculating standardized unemployment rates.

NOTE: Detail may not add to total because of rounding.

SOURCE: National Science Foundation/SRS, 1993 Survey of Doctorate Recipients.

(table 3). Perhaps most interesting is that the unemployment rate for those born outside the United States (2.0 percent) is somewhat higher than for those born in this country (1.5 percent). However, the association between place of birth and unemployment rate was not statistically significant when controls were made for other variables, including years from doctorate and field of degree—both of which are associated with being born in the United States[24] and are likely to be associated with place of birth within the United States.

Disability Status

Disability status was significantly related to the unemployment rate in the 1993 doctoral science and engineering population (table 4). Those who reported difficulty walking had a 3.4-percent unemployment rate; the rate was 3.6 percent for those with difficulty lifting and 3.0 percent for those with hearing disabilities—compared to the overall Ph.D. unemployment rate of 1.6 percent. However, those with difficulty seeing had an unemployment rate of 1.9 percent—only slightly above average. Since the incidence of disabilities increases with age, and unemployment rates tend to be higher in the older population, age can be expected to explain part of the observed difference. This appears to be the case, although standardization does not eliminate the association between disability status and unemployment for individuals with disabilities other than vision.

Age and Time Since Completion of Degree

Unemployment rates in the doctoral science and engineering population increased steadily with age in 1993—from 1.1 percent for those under 35 to 4.2 percent for those 65 and older (chart 3). However, standardized values were not calculated for age, because time since completion of degree and age at the time of receiving the doctorate were included, and it is not possible to include all three variables in the same multivariate analysis.[25]

An important factor in explaining the unemployment rate in 1993 was the elapse of time since completion of degree. However, the relationship was not linear (chart 4). Unemployment was highest at the extremes of the distribution. The unemployment rate was 3.0 percent for those who received degrees 10 or 11 months before the interview, and 2.2 percent for those

[24] See NSF 96-311.

[25] See the Technical Notes for further discussion of this point.

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Table 3. Unemployment rates for doctoral scientists and engineers, by place of birth: 1993

Region/State of Birth	Population Size	Actual Unemployment Rate -- by Percent
New England	26,480	1.4
Connecticut	6,360	1.3
Massachusetts	15,150	1.4
Other	4,960	1.4
Middle Atlantic	104,270	1.5
New Jersey	15,740	1.3
New York	59,990	1.7
Pennsylvania	28,540	1.4
East North Central	76,060	1.7
Illinois	26,640	1.8
Indiana	8,120	1.6
Michigan	13,380	1.5
Ohio	19,310	1.6
Wisconsin	8,620	2.3
West North Central	36,430	1.2 *
Minnesota	8,470	0.8 *
Missouri	8,830	1.0
Other	19,140	1.4
South Atlantic	37,210	1.0 *
District of Columbia	5,590	0.6 *
Florida	5,090	0.6 *
Maryland	5,050	1.7
North Carolina	5,310	2.3
Virginia	5,070	0.3 *
Other	11,100	0.8 *
East South Central	14,980	2.0
West South Central	26,490	1.8
Texas	14,870	1.5
Other	11,620	2.2
Mountain	16,380	2.1
Pacific	38,580	1.5
California	28,260	1.7
Washington	5,350	1.0
Other	4,980	1.0
Other	93,630	2.0 *
All individuals	470,500	1.6

* Difference between unemployment rate observed in geographic area and total unemployment rate excluding those in the group is statistically significant at .05 level.

NOTE: Detail may not add to total because of rounding.

SOURCE: National Science Foundation/SRS, 1993 Survey of Doctorate Recipients.

Table 4. Unemployment rates for doctoral scientists and engineers, by disability status: 1993

Disability status	Population Size	Actual Unemployment Rate	Standardized Unemployment Rate[1]
		by Percent	
Not Disabled	446,760	1.6	1.6
Disabled:			
Disability related to seeing	8,290	1.9	1.6
Disability related to hearing	11,360	3.0 *	2.5
Disability related to walking	3,470	3.4	2.7
Disability related to lifting	4,860	3.6 *	2.5

* Difference between unemployment rate observed in disability status group and total unemployment rate excluding those in the disability status group is statistically significant at .05 level.

[1] See the Technical Notes for an explanation of the adjustment methodology used in calculating standardized unemployment rates.

NOTE: Detail may not add to total because of rounding.

SOURCE: National Science Foundation/SRS, 1993 Survey of Doctorate Recipients.

who received degrees 25 or more years ago.[26] Unemployment rates showed little difference among those who received degrees between 1 and 24 years; previously, these rates ranged from 1.3 percent to 1.7 percent.

An examination of the relationship between time since completion of the doctorate and the unemployment rate, controlling for the other variables in this analysis, confirmed that years since completion of the doctorate is an important determinant of unemployment. Indeed, this relationship is even stronger after controlling for the other variables in this analysis. The standardized unemployment rates ranged from 0.4 percent for those who received degrees between 10 months and 3 years prior to data collection to 4.5 percent for those who received degrees 30 years earlier. These standardized scores are calculated using the assumption that individuals have equal values on the variables in this analysis other than the one being examined. In this case, it is important to note that included in the control variables are years of full-time work experience and age at time of receiving the doctorate. Thus, unemployment rates rose with age (equal to age at receiving the doctorate plus years since the doctorate) among those who were the same age at the time they graduated and who had the same number of years of work experience.

Factors Relevant for Career Decisions

Educational Decisions

Field of Degree

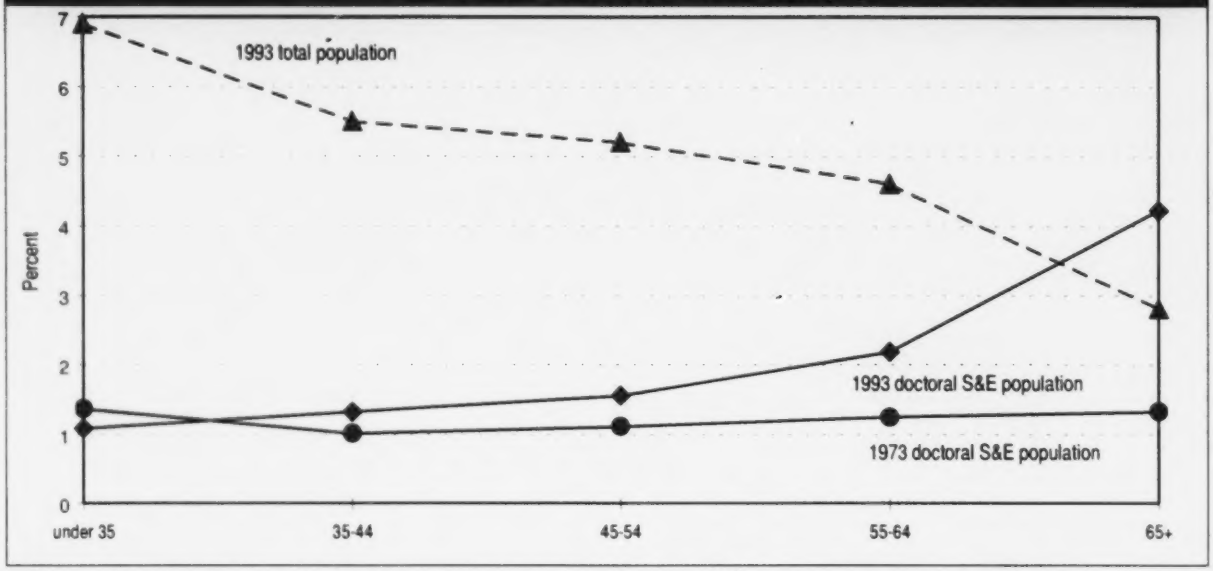
Unemployment rates vary significantly by degree field, according to data from the 1993 Survey of Doctorate Recipients (SDR) (table 5). Unemployment rates ranged from 0.6 percent in civil engineering to 2.5 percent in the geological and environmental sciences. However, there were no statistically significant differences among broad degree field categories of natural science and mathematics, social sciences, and engineering.

Standardized unemployment rates for field of degree indicate that controlling for other variables does not diminish the strength of the relationship between field of degree and unemployment.[27] The range for

[26] Note that 1993 graduates were not included in this sample; therefore, no information is available for those who received degrees fewer than 10 months earlier.

[27] See Text Box for brief explanation of standardization techniques used in this study and Technical Notes for more detailed explanation.

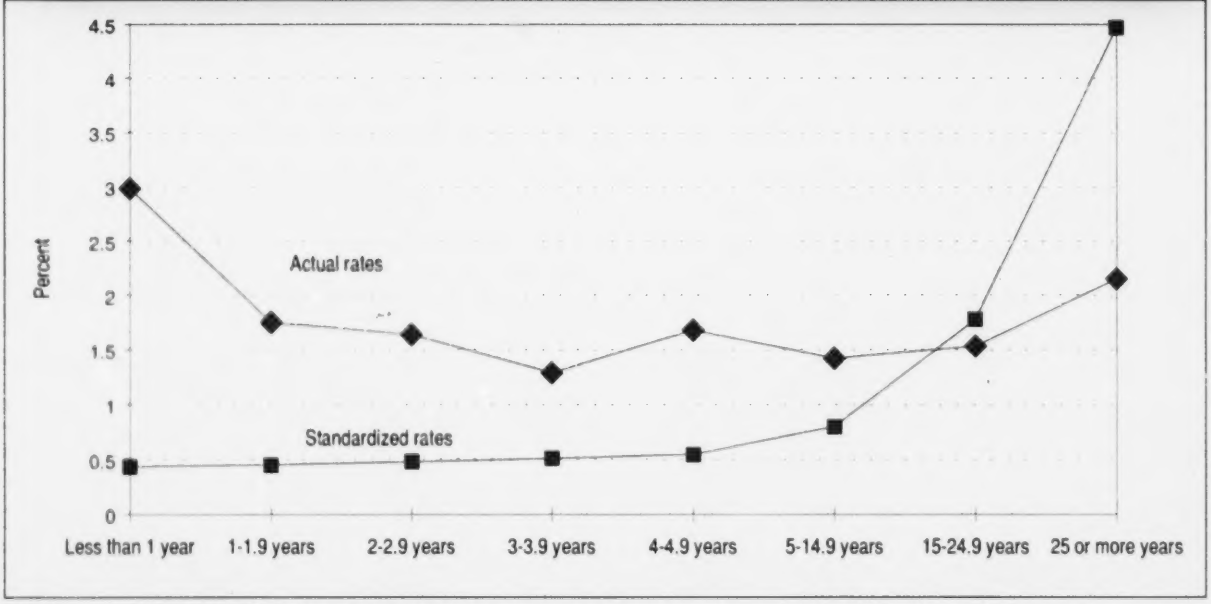
Chart 3. Unemployment rates of persons with doctoral degrees in science and engineering in 1973 and 1993 and in the total population in 1993, by age



NOTE: See the Technical Notes for an explanation of the adjustment methodology used in calculating standardized unemployment rates.

SOURCES: Doctoral statistics from National Science Foundation/SRS, 1993 Survey of Doctorate Recipients. General population figures from Bureau of Labor Statistics, 1993 Current Population Survey.

Chart 4. Unemployment rates of persons with doctoral degrees in science and engineering,by year since doctorate: 1993



NOTE: See the Technical Notes for an explanation of the adjustment methodology used in calculating standardized unemployment rates.

SOURCE: National Science Foundation/SRS, 1993 Survey of Doctorate Recipients.

standardized unemployment rates is 0.5 to 2.4 percent. However, the magnitude of unemployment rates within some fields shift considerably when controlling for other variables.

What is more surprising than the existence of a statistically significant relationship between detailed degree field and unemployment rate is that the effect is not more dramatic. None of the rates approached those observed in the general population.

Age at Completing the Doctorate

Individuals planning to pursue doctorates face a number of decisions that affect the age at completing the doctorate. Individuals must decide whether to enroll in graduate school immediately after completing their baccalaureate, to go directly to work, or to pursue other interests. In selecting a department, individuals may use information about the length of time it usually takes students in different departments to complete a degree. Further decisions affecting age at completing the degree are made after enrollment. For example, a student may consider pursuing a graduate degree on a part-time basis in order to have children. Of course, decisions under the individuals' control do not always determine the age at which the doctorate is received. Changes in academic requirements, the availability of financial resources, and personal problems (such as illness) also affect the age at completing the doctorate.

Table 5. Unemployment rates for doctoral scientists and engineers, by degree field: 1993

Degree Field	Population Size	Actual Unemployment Rate	Standardized Unemployment Rate[1]
		by Percent	
Natural Sciences and Mathematics	254,240	1.7	1.6
Agricultural sciences	15,390	1.9	2.4
Biological sciences	107,180	1.4	1.5
Chemistry	52,710	1.8	1.2
Geological and environmental sciences	16,770	2.5 *	2.4
Mathematical and computer sciences	28,260	1.1 *	1.2
Physics and astronomy	33,930	2.3 *	2.2
Social Sciences	138,690	1.4	1.7
Economics	19,690	1.4	2.0
Political science	14,580	2.0	2.2
Psychology	71,950	1.3 *	1.8
Sociology/Anthropology	20,110	1.6	1.3
Other social sciences	12,350	1.5	1.3
Engineering	76,440	1.7	1.5
Chemical engineering	11,340	1.8	1.5
Civil engineering	7,100	0.6 *	0.5
Electrical engineering	19,780	1.9	1.8
Mechanical engineering	9,560	1.0	0.9
Other engineering	28,650	2.1	1.6
All Fields**	470,500	1.6	1.6

* Difference between unemployment rate observed in field and total unemployment rate excluding those in the field is statistically significant at .05 level.

** The total includes individuals in fields not displayed because of small sample sizes.

[1] See the Technical Notes for an explanation of the adjustment methodology used in calculating standardized unemployment rates.

NOTE: Detail may not add to total because of rounding.

SOURCE: National Science Foundation/SRS, 1993 Survey of Doctorate Recipients.

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Age at completing the doctorate has a statistically significant association with unemployment. For those receiving a doctorate before age 26, the unemployment rate was 1.2 percent; for those who were 40 or older, the rate was 3.7 percent (chart 5).

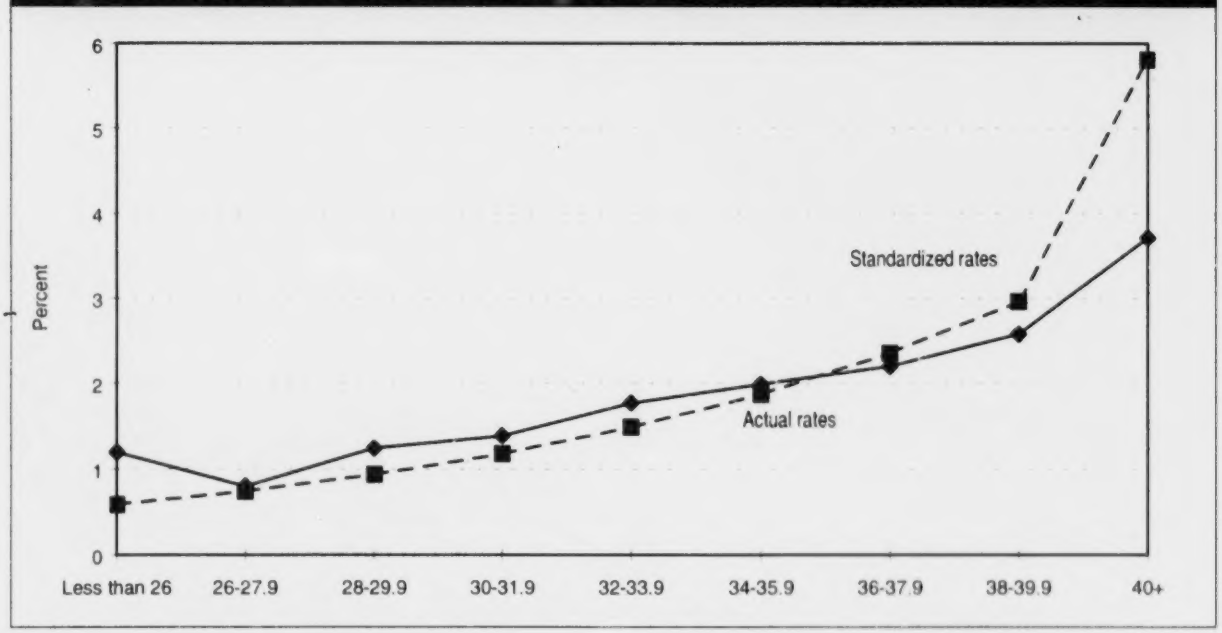
Calculating standardized unemployment rates indicates that the age at completing the doctoral degree is an even more important determinant of unemployment than was apparent from examination of the actual unemployment rates. Standardized unemployment rates ranged from 0.6 to 5.8 percent.

The fairly strong relationship between age at the time of receiving the doctorate and unemployment is not surprising, since receiving a doctorate at an early age can be an indicator of an individual's ability to get work done quickly and efficiently. It is, of course, not possible to determine whether the primary reason for this relationship is because potential employers are using age at completing the doctorate as a screening device or because those who complete their doctorates at a young age do indeed possess superior work skills. Also, no distinction is made in this analysis among individuals with differing reasons for receiving their doctorates at above average ages. Additional exploration of this issue might, for example, point to differences between those who spent 12 years enrolled in graduate school and those who spent 7 years working prior to 5 years of graduate school. It should also be noted that individuals who receive their degrees later in life are older, on average, than individuals who receive their degrees at a younger age. The standardized rates do not fully control for this fact.

Amount of Work Experience

A variety of situations may cause an individual to consider voluntarily dropping out of the labor force or working part-time—including a desire to spend more time with young children or aging relatives, or simply taking time off to explore the world. There are also times when individuals need to choose between career paths offering different levels of job security. Careers may also be interrupted by factors beyond an individual's control. According to conventional wisdom, interruptions in full-time employment after completion of education can be harmful to an individual's future

Chart 5. Unemployment rates of persons with doctoral degrees in science and engineering, by age at doctorate: 1993



NOTE: See the Technical Notes for an explanation of the adjustment methodology used in calculating standardized unemployment rates.

SOURCE: National Science Foundation/SRS, 1993 Survey of Doctorate Recipients.

career. In this section, three basic indicators of career continuity—full-time work experience, prior period non-employment, and part-time work experience—are examined to determine how accurate this conventional wisdom is.

Full-time Work Experience

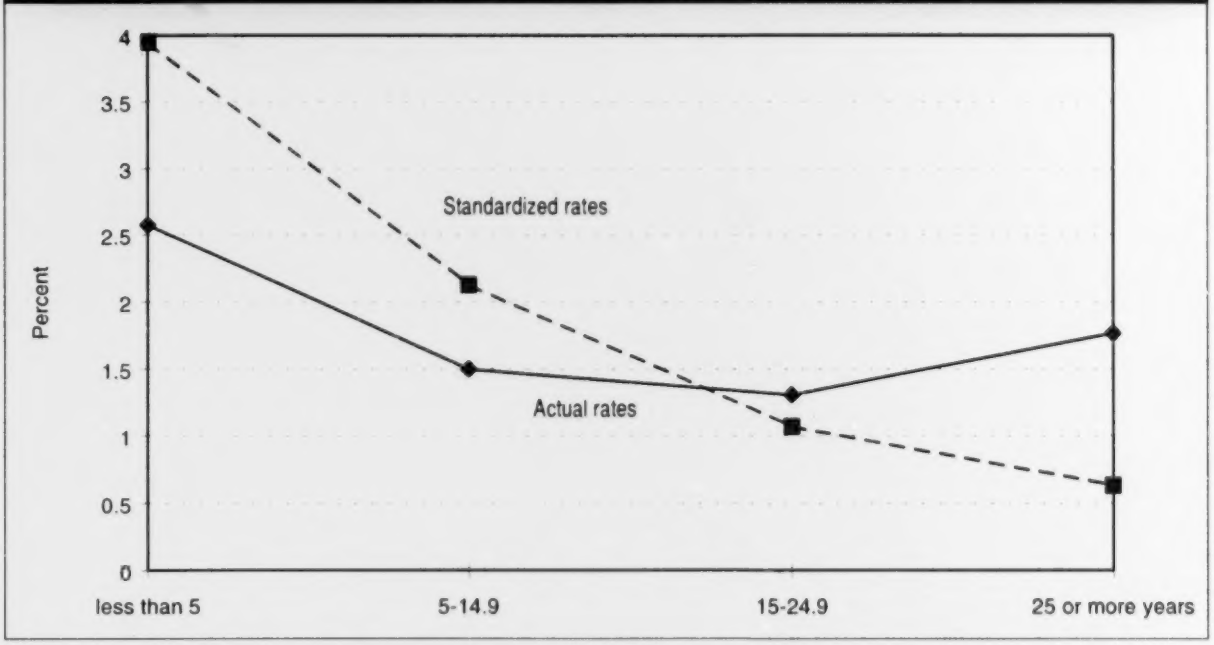
The unstandardized relationship between years of full-time work experience and unemployment is not linear (chart 6). Those with fewer than 5 years of experience and those with 25 or more years of full-time work experience were more likely to be unemployed than those with intermediate lengths of work experience. The unemployment rates among those with fewer than 5 years of full-time work experience were 2.6 percent; for those with 25 or more years, it was 1.8 percent. However, the unstandardized relationship does not take into account that the number of years of work experience is dependent upon the opportunity to work. For example, young workers have not had time to accumulate long work histories.

After controlling for other variables in this analysis, the relationship between full-time work experience and unemployment indicates that unemployment declines with increasing years of full-time work experience. The standardized unemployment rate for individuals with 2.5 years of full-time work experience was 3.9 percent, compared to 0.6 percent for those with 30 years of full-time experience. Therefore, among individuals completing their doctorates at the same time, the factor of additional years of full-time work experience appears to decrease the probability of unemployment. Because of the strong association between years since receipt of the doctorate and years of work experience, this relationship is obscured in looking at actual unemployment rates.

Prior Non-Employment

There are two factors that cause us to expect that prior period unemployment will lead to a higher probability of unemployment in the present. First, some of the factors that affect unemployment, such as age at

Chart 6. Unemployment rates of persons with doctoral degrees in science and engineering, by years of full-time work experience: 1993



NOTE: See the Technical Notes for an explanation of the adjustment methodology used in calculating standardized unemployment rates.

SOURCE: National Science Foundation/SRS, 1993 Survey of Doctorate Recipients.

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receiving the doctorate, are permanent characteristics of the individual. Second, periods of prior unemployment are likely to be viewed negatively by prospective employers—at least partly due to the concern that scientific knowledge may be out-of-date after a period of unemployment. The variable in the 1993 SDR that most closely measures prior unemployment is the question on whether the respondent was employed in April 1988. Among those who were not employed in 1988, but were in the labor market in April 1993, the unemployment rate was 4.1 percent, compared to 1.5 percent for those who were employed in April 1988 (table 6).

Although the SDR does not permit differentiating between non-employment in 1988 associated with being unemployed and non-employment attributable to being out of the labor force, it is possible to calculate separate 1993 unemployment rates for individuals who received doctorates before 1988 and those who received them during or after 1988. For the latter group, unemployment rates did not differ significantly from those who were employed in 1988. However, among individuals who received doctorates before 1988, the unemployment rate was 9.6 percent, the highest rate observed in this study.

Table 6. Unemployment rates for doctoral scientists and engineers, by occupation in 1988: 1993

1988 Occupation	Population Size	Actual Unemployment Rate	Standardized Unemployment Rate[1]
		by Percent	
Not employed in 1988	27,460	4.1 *	3.3
Post-1988 doctorates	19,090	1.6	1.7
Pre-1988 doctorates	8,370	9.6 *	6.8
Employed in 1988***	443,050	1.5 *	1.5
Science and engineering postsecondary teachers	116,200	0.7 **	0.6
Math/computer science	16,560	0.6 **	0.8
Life sciences	27,300	0.5 **	0.5
Physical sciences	19,420	0.4 **	0.4
Social sciences	38,320	1.0 **	0.8
Engineering	14,600	0.4 **	0.5
Other science and engineering occupations	202,580	1.9 **	2.1
Mathematical and computer scientists	16,750	2.6 **	2.7
Agricultural scientists	8,600	1.0	0.8
Biological scientists	43,920	1.8	2.1
Chemists	22,030	2.9 **	4.8
Geologists and environmental scientists	9,070	1.9	1.3
Physicists	14,600	2.3	1.9
Psychologists	1,540	0.6 **	0.4
Other social scientists	34,080	1.4	1.1
Electrical engineers	12,140	1.8	1.7
Other engineers	9,440	2.5 **	3.1
Non-science and engineering occupations	30,430	1.5	1.4
Managerial and professional2	35,670	1.3	1.4
Other non-science and engineering2	124,260	2.1 **	1.2
All individuals***	470,500	1.6	1.6

* Difference between observed unemployment rate and unemployment rate for total population, excluding those in category, is statistically significant at .05 level.

** Difference between observed unemployment rate and unemployment rate for employed population, excluding those in category, is statistically significant at .05 level.

*** The total includes individuals in categories not displayed because of small sample sizes.

[1] See the Technical Notes for an explanation of the adjustment methodology used in calculating standardized unemployment rates.

[2] See the Technical Notes for an explanation of occupations included in this category.

NOTE: Detail may not add to total because of rounding.

SOURCE: National Science Foundation/SRS, 1993 Survey of Doctorate Recipients.

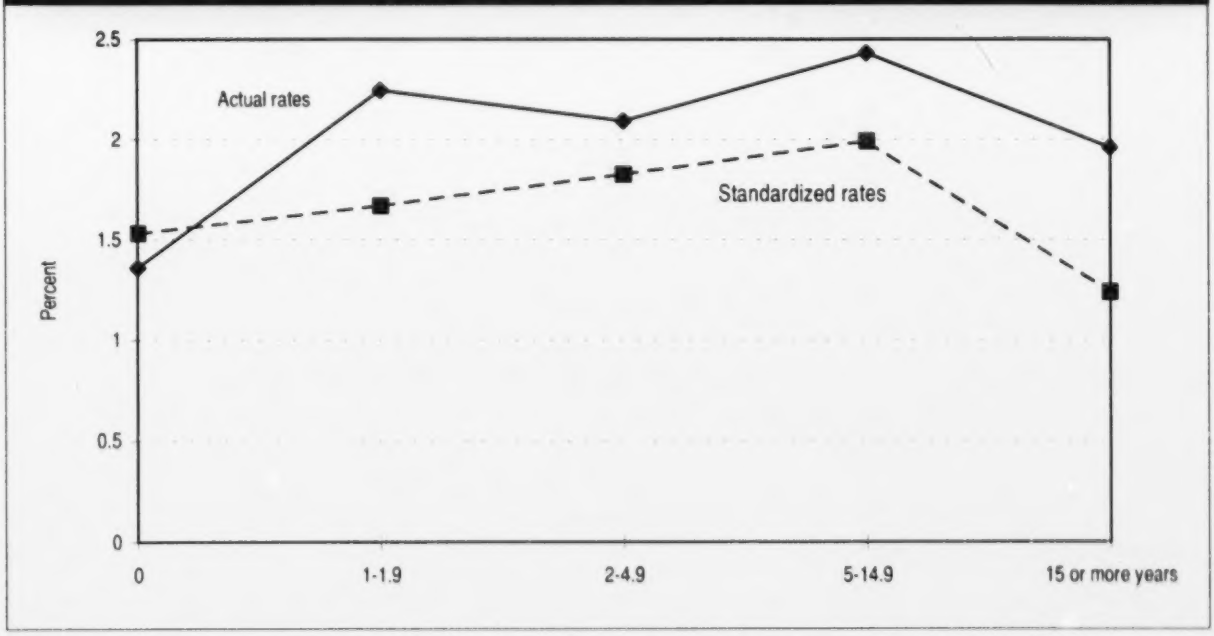
One reason for the high 1993 unemployment rate of those not employed in 1988 might be that many unemployed individuals have characteristics (such as age at degree and degree field) that predispose them to having high unemployment rates throughout their careers. Although the high unemployment rate for pre-1988 doctorates who were not employed in 1988 was reduced by controlling for the other variables in this analysis (from 9.6 to 6.8 percent), the standardized unemployment rate remains high relative to that for the doctoral population as a whole. It is likely that this association is at least partly explained by factors other than those measured in this study.

Part-Time Work Experience

Prior part-time employment, regardless of the number of years of work experience, appears to increase the likelihood of unemployment. Those with no part-time employment (70 percent of the total population) had an unemployment rate of 1.4 percent; those with part-time employment had rates ranging from 2.0 to 2.4 percent (chart 7). Part-time employment may indicate a relatively low commitment to labor market participation that is viewed unfavorably by employers. However, it is also possible that the same factors that led to earlier part-time employment (for example, poor health, family responsibilities) may affect employability later.

There is a curvilinear relationship between standardized unemployment rates and years of part-time employment—those at the extremes of the distribution on part-time employment have the lowest unemployment rates. However, the relationship is weak—unemployment rates ranged from 1.2 to 2.0 percent. One plausible explanation is that the experience obtained from part-time employment is approximately balanced by the negative connotation of part-time versus full-time employment.

Chart 7. Unemployment rates of persons with doctoral degrees in science and engineering, by years of part-time work experience: 1993



NOTE: See the Technical Notes for an explanation of the adjustment methodology used in calculating standardized unemployment rates.

SOURCE: National Science Foundation/SRS, 1993 Survey of Doctorate Recipients.

Other Career Choices

Occupation

Occupation is widely recognized to affect employability. For example, in April 1993, the unemployment rate among individuals ages 16 and over within the U.S. population in managerial and professional specialty occupations was less than half that for all occupations—3.1 percent compared to 7.1 percent.[28]

The unemployment rate in 1993 varied by the occupation held in 1988 (table 6). The observed rates ranged from under 0.4 percent for postsecondary teachers in the physical sciences and engineering to 2.9 percent for chemists. In general, those employed as postsecondary teachers in 1988 had lower unemployment rates than those employed in non-teaching occupations in allied fields. For example, among those employed as postsecondary teachers of mathematics or computer science in 1988, the unemployment rate was 0.6 percent, compared to 2.6 percent for other types of computer scientists or mathematicians. Among those not in the science and engineering professions, those who entered managerial and professional specialty occupations were somewhat less likely to be unemployed—1.3 percent, compared to 2.1 percent for those who were in other non-S&E occupations in 1988.[29]

The examination of standardized unemployment rates by occupation in 1988 confirms the importance of 1988 occupation in predicting 1993 unemployment rates. The difference between individuals who held positions as postsecondary teachers and non-postsecondary teachers in similar fields also remained after standardization. However, the difference in unemployment rates between those with employment in different types of non-S&E occupations in 1988 was eliminated by the controls. In other words, the apparent relationship was a function of other differences between the two groups.

Sector

The sector that employed the individual in 1988 had a fairly strong relationship with unemployment in 1993 (table 7). Among those who received degrees before 1988, the unemployment rate ranged from 0.6

Table 7. Unemployment rates for doctoral scientists and engineers, by employment sector in 1988: 1993

1988 Employment Sector	Population Size	Actual Unemployment Rate	Standardized Unemployment Rate[1]
		by Percent	
Employed in 1988	443,050	1.5	1.5
Medical school	32,270	0.6 **	0.7
University-affiliated research institute	23,140	1.6	1.4
Other four-year college/university	169,710	1.1 **	1.0
Other educational employer	10,090	1.2	0.7
Private for profit employer	111,980	2.6 **	3.1
Self-employed -- incorporated	9,590	1.2	0.7
Self-employed -- not incorporated	19,740	1.0	0.4
Private not for profit employer	21,560	1.4	1.2
State government	8,240	0.8	0.6
U.S. government -- civilian position	27,980	1.0 **	1.0
Other employer	8,750	2.1	1.9
All individuals	470,500	1.6	1.6

* Difference between observed unemployment rate and unemployment rate for employed population, excluding those in category is statistically significant at .05 level.

[1]See the Technical Notes for an explanation of the adjustment methodology used in calculating standardized unemployment rates.

NOTE: Detail may not add to total because of rounding.

SOURCE: National Science Foundation/SRS, 1993 Survey of Doctorate Recipients.

[28] Bureau of Labor Statistics 1996.

[29] See the Technical Notes for an explanation of how this classification of non-S&E occupations was made.

percent for medical schools to 2.6 percent for private-for-profit institutions. In general, low unemployment rates were associated with employment in educational institutions in 1988 (ranging from 0.6 percent to 1.2 percent if university-affiliated research institutions are excluded). Employment with the Federal Government in a civilian capacity (1.0 percent) or with state government (0.8 percent) also resulted in low 1993 unemployment rates.

Examining the standardized relationship between type of 1988 employer and 1993 unemployment rate (among those who were employed in 1988) did not substantially change the findings about the relationship between these two variables.

Geographic Location

Geographic location of residence and work is another employment-related decision individuals make. Because unemployment is higher in some parts of the country than in others,[30] it is reasonable to expect that state or region of employment (or residence if the individual is not employed) is associated with the unemployment rate for doctoral scientists and engineers. This is, in fact, the case (table 8). Unemployment rates for doctoral scientists and engineers ranged from 0.3 percent in the less-populated states in the West North Central region (Iowa, North Dakota, South Dakota, Nebraska, and Kansas) to 2.8 percent in California. Standardization did not have a substantial impact on the relationship between state of residence/employment and unemployment—standardized unemployment rates by state ranged from 0.5 to 2.7 percent.

Conclusions

Differences in unemployment rates between men and women, among racial/ethnic minorities, and between those born in the United States and those born elsewhere were not statistically significant in this study's multivariate analysis. However, unemployment rates were higher than average among individuals with mobility and hearing disabilities and individuals who completed doctorates more than 25 years before the survey, after controlling for the other variables included in the study. Further, marriage and children were associated with higher than average unemployment rates for women, but lower than average unemployment rates for men. These results, it is important to emphasize, are based on an imperfect multivariate analysis that can support, but not prove, causal relations between variables.

The analysis indicates that among those who hold U.S. doctorates in science and engineering, not being employed or being employed only part-time for a period of time may negatively influence future employability. Occupation, sector of employment, and geographic location are related to the likelihood of becoming unemployed. The risk associated with these choices is small, however, compared to the risks for the general population. The highest standardized 1993 unemployment rate in these analyses was 6.8 percent for the approximately 8,000 individuals who were neither employed nor students in 1988.

[30] See, for example, NSF 1972, pp. 26–29 and p. 73.

Table 8. Unemployment rates for doctoral scientists and engineers, by location of employment[1]: 1993

Regional/State of Employment	Population Size	Actual Unemployment Rate	Standardized Unemployment Rate[2]
		by Percent	
New England	36,760	1.4	1.4
Connecticut	7,610	1.2	1.3
Massachusetts	21,660	1.4	1.3
Other	7,490	1.5	1.9
Middle Atlantic	81,510	1.3 *	1.3
New Jersey	19,580	1.3	1.1
New York	39,590	1.2 *	1.2
Pennsylvania	22,340	1.6	1.7
East North Central	64,770	1.4	1.5
Illinois	19,380	1.2	1.2
Indiana	7,690	1.0	1.2
Michigan	13,180	1.3	1.4
Ohio	17,070	2.2	2.3
Wisconsin	7,450	0.5 *	0.6
West North Central	27,820	0.9 *	1.0
Minnesota	8,170	1.8	1.9
Missouri	8,030	0.7 *	0.9
Other	11,620	0.3 *	0.5
South Atlantic	88,480	1.3 *	1.4
District of Columbia	13,600	0.7 *	0.7
Florida	12,060	2.4	2.4
Maryland	18,760	2.0	1.8
North Carolina	12,420	1.6	1.9
Virginia	13,830	0.9 *	0.9
Other	17,800	0.6 *	0.7
East South Central	19,200	1.1 *	1.2
West South Central	37,960	1.8	1.8
Texas	26,390	2.0	2.0
Other	11,560	1.3	1.6
Mountain	30,190	2.6 *	2.7
Pacific	82,120	2.5 *	2.3
California	62,230	2.8 *	2.5
Washington	10,780	1.9	1.8
Other	9,110	1.1	1.1
Other	1,700	1.1	1.0
All individuals	471,000	1.6	1.6

* Difference between unemployment rate observed in geographic area and total unemployment rate excluding those in the geographic area is statistically significant at .05 level.

[1] Unemployed individuals are classified by the location of their residence.

[2] See the Technical Notes for an explanation of the adjustment methodology used in calculating standardized unemployment rates.

NOTE: Detail may not add to total because of rounding.

SOURCE: National Science Foundation/SRS, 1993 Survey of Doctorate Recipients.

IV. Changes in Factors Affecting Unemployment Since 1973

Introduction

Over time, have the factors affecting unemployment in the doctoral science and engineering population changed? This section attempts to answer this question by comparing the results for 1993 with relevant information published from the 1973 SDR.[31]

Demographic Factors

Gender

The association between gender and unemployment in the doctoral science and engineering population was markedly different in 1973 than in 1993. Maxfield et al. found that "the unemployment rate for women was substantially higher than that for men (3.9 percent versus 0.9 percent in 1973)."[32] The researchers further demonstrated that the existence of a strong gender effect remained when controlling for either degree field or age differences. The unemployment rates for degree field ranged from 0.6 to 1.4 percent for men and 1.9 to 6.8 percent for women (Maxfield et al., p. 8). The unemployment rates, when controlling for age, ranged from 0.6 to 1.6 percent and 1.1 to 6.0 percent, respectively. In all age groups and degree fields, women had considerably higher unemployment rates than men. The smallest reported difference was in the field of mathematics, where the rate was 1.9 percent for women compared to 1.4 percent for men.

The lack of a statistically significant gender gap in 1993 is very different from NSF's early 1970s findings for a more broadly defined science and engineering population. In that study, 5.2 percent of female scientists were unemployed, compared to 2.3 percent of men and 15 percent of the few female engineers studied. Department of Labor researchers have noted a similar narrowing of the unemployment gap between men and women in the general population.[33]

Age

In 1973, the relationship between unemployment and age in the doctoral population was considerably weaker than in 1993 (chart 3). The 1973 rates, which ranged from 1.0 to 1.4 percent, were quite small and consistent with chance fluctuation. In contrast, 1993 rates ranged from 1.1 to 4.2 percent. Differences between 1973 and 1993 unemployment levels for ages 45 years and older were statistically significant, although the differences for the under-45 categories were not.

Factors Relevant to Career Decisions

In 1973 and 1993, the relationship between degree field and unemployment was discernible, though not particularly strong (table 9). The fields that had unusually high or low unemployment were different in both years, however. For example, physics and astronomy had an above average unemployment rate in 1993; in 1973 it was only slightly (and not statistically significantly) above average. Engineering and social sciences, with average unemployment rates in 1993, had significantly below average rates in 1973. The association between the unemployment rates in the two years was negligible (r = .24).

The observed changes between the 1973 and 1993 unemployment rates could be due to sampling error. For example, the observed 1993 unemployment rate for physicists and astronomers has a 95 percent confidence interval from 1.7 to 2.9 percent. Thus, it is possible that the unemployment rate for physicists and astronomers was only slightly above average for both

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[31] It should be noted that in the *1973 Characteristics of Doctoral Recipients*, published by SRS/NSF, information on unemployment rates by race/ethnicity was included. However, at the point in time of the study, racial/ethnic minorities were not oversampled, and the available data are not useful for current purposes.

[32] *Op. cit.*, p. 5. Note that methodological differences between the 1973 SDR and the 1993 SDR result in population estimates that are not strictly comparable between the two surveys. For example, the 1973 survey included individuals with degrees from non-U.S. institutions, while the 1993 SDR did not. Although possible, it is unlikely that the survey changes completely explain the 1973 and 1993 differences.

[33] U.S. Department of Labor, p. 32.

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Table 9. Unemployment rates for doctoral scientists and engineers, for selected degree fields: 1973 and 1993

Degree Field	1973	1993
	by Percent	
Life sciences	1.1	1.5 *
Mathematical and computer sciences	1.4	1.1
Chemistry	1.7	1.8
Physics and astronomy	1.5	2.3 *
Psychology	1.2	1.3
Other social sciences	0.9	1.6 *
Engineering	0.8	1.7 *
All Fields**	1.2	1.6 *

* Difference between 1973 and 1993 unemployment rates is statistically significant at .05 level, using approximate test.

** The total includes individuals in fields not displayed, because of small sample sizes.

NOTES: Information is presented only for degree field categories believed to be comparable during 1973 and 1993. Detail may not add to total because of rounding.

SOURCES: National Science Foundation/SRS, 1993 Survey of Doctorate Recipients. National Research Council, *Employment Status of Ph.D. Scientists and Engineers 1973 and 1975.*

years. These chance fluctuations contribute to the low correlation between the 1973 and 1993 rates. The true association may be more substantial than observed.

The low association of unemployment rates among degree fields in 1973 and 1993 is consistent, however, with the economic theory that, over time, markets tend toward equilibrium. For example, when changing demand leads to the scarcity of a skill, traditional economic theory predicts that the market will respond by increasing salaries for that skill, which, in turn, will induce more individuals to obtain the scarce skill, thereby increasing the supply of skilled individuals. There is no a priori reason to believe that this equilibrating force is inoperative in doctoral labor markets, even though the time it takes to complete a doctoral degree may make responses slower than for more easily obtained skills.

If individuals entering graduate school in 1973 had selected their degree fields on the basis of 1973 unemployment rates, they would not have significantly decreased their probability of being unemployed in 1993.

The strength of the association of unemployment with region of employment or residence was also similar in both years. In 1973 and 1993, the highest regional unemployment rate was slightly less than three times the lowest rate (table 10). However, unlike degree field, the ordering of the 1973 and 1993 rates appears to show some consistency ($r = .45$). In all three cases in which the unemployment rate was significantly above or below average in both years, the rates were in the same direction. In seven of the nine comparisons in which the unemployment rate was statistically above or below average in only one of the two years, the other unemployment rate was consistent in direction. Thus, if doctoral graduates had used the 1973 information on unemployment rates by region to assist them in choosing where to live, they may well have decreased their probability of becoming unemployed later.

Although the National Academy of Sciences studies did not report on the impact of sector on unemployment, the relative stability of employment in both academia and the Federal Government was documented in the 1972 NSF study.[14]

[14] NSF 1972, p. 68.

Table 10. Unemployment rates for doctoral scientists and engineers, by geographic location of employment[1]: 1973 and 1993

Region/State of Employment	1973	1993	Region/State of Employment	1973	1993
	by Percent			by Percent	
New England	1.2	1.4	South Atlantic	1.0	1.3
Connecticut	1.3	1.2	District of Columbia	1.0	0.7
Massachusetts	1.0	1.4	Florida	1.7	2.4
Other	1.5	1.5	Maryland	0.7	2.0 *
			North Carolina	1.1	1.6
Middle Atlantic	1.2	1.3	Virginia	1.1	0.9
New Jersey	1.3	1.3	Other	0.6	0.6
New York	1.4	1.2			
Pennsylvania	0.8	1.6 *	East South Central	0.6	1.1
East North Central	1.0	1.4	West South Central	0.9	1.8 *
Illinois	1.2	1.2	Texas	1.0	2.0 *
Indiana	0.9	1.0	Other	0.6	1.3
Michigan	1.2	1.3			
Ohio	0.9	2.2 *	Mountain	1.6	2.6 *
Wisconsin	0.9	0.5			
			Pacific	1.5	2.5 *
West North Central	1.1	0.9	California	1.6	2.8 *
Minnesota	1.0	1.8	Washington	1.6	1.9
Missouri	1.4	0.7	Other	1.1	1.1
Other	0.9	0.3			
			Other	--	1.1
			All individuals	1.2	1.6 *

* Difference between 1973 and 1993 unemployment rates is statistically significant at .05 level, using approximate test.

[1] Unemployed individuals are classified by the geographic location of their residence.

NOTE: Detail may not add to total because of rounding.

SOURCES: National Science Foundation/SRS, 1993 Survey of Doctorate Recipients. National Academy of Sciences, *Doctoral Scientists and Engineers in the United States, 1973 Profile*.

CONCLUSIONS

Important changes occurred in the relationships between demographic variables and unemployment rates between 1973 and 1993. The association between gender and unemployment rates declined substantially. In contrast, age had a stronger association with unemployment in 1993 than in 1973. Considerable change in the ordering of unemployment rates by degree fields was observed between the two years. However, the relationships between unemployment and place of employment/residence and unemployment and sector were similar.

V. Conclusions and Future Research

Conclusions

Several analyses related to unemployment among individuals with doctoral degrees in science and engineering were presented in this report. Unemployment was relatively high in this population in 1993 compared to earlier years; however, the ratio between unemployment among doctoral scientists and engineers and total population unemployment in 1993 was essentially unchanged.

Neither gender nor race/ethnicity had a statistically significant association with unemployment in 1993. A hearing or mobility disability or advanced age, however, appeared to increase the probability of being unemployed.

The association between gender and unemployment was much stronger in 1973 than in 1993. In contrast, the association between age and unemployment was stronger in 1993 than in 1973.

Unemployment in the Larger Career Context

Unemployment is not merely an economic phenomenon, from the individual's perspective, but one of many career possibilities at a particular point in time. Individuals unable to obtain the type of employment they consider desirable may settle for a job that has serious drawbacks. For example, a part-time job may be accepted when a full-time job is preferred, or a position in a field other than that of the doctoral field may be accepted when an in-field position is preferred. It is reasonable to expect that the unemployment rate will not only reflect how difficult it is to obtain suitable employment, but will also reflect differences in individuals' preferences and the availability of less desirable opportunities for employment. A factor associated with an above average level of unemployment is, therefore, not necessarily associated with other adverse career outcomes.

For example, in 1993, those who had degrees in psychology had a below average unemployment rate relative to other doctoral scientists and engineers, but an above average involuntary part-time employment rate. One plausible explanation for this discrepancy is the greater opportunities for self-employment in psychology than in other doctoral science and engineering fields. Over a quarter of individuals in the labor force with doctoral degrees in psychology reported they were self-employed in April 1993, compared to a range of 3 to 8 percent for other degree fields examined. Thus, individuals with psychology degrees who have difficulty obtaining full-time employment presumably have greater opportunities for part-time self-employment. This hypothesis is further supported by the fact that the involuntary part-time rate for those who are self-employed is relatively high—3.8 percent—compared to 1.0 percent for individuals not self-employed.

Although a full exploration of these alternative measures is beyond the scope of this report, the observed unemployment, involuntary part-time employment, and involuntary out-of-field rates are presented in table A-1. Examination of the associations between unemployment, involuntary part-time employment, and involuntary out-of-field employment across all subgroups examined in this study indicated that there were weak, but positive, associations between these different indicators of stress in the labor market ($r = .35$ for the associations between unemployment and involuntary part-time employment and between unemployment and involuntary out-of-field employment, and $r = .13$ between involuntary part-time and involuntary out-of-field employment).

In sum, although the information in this report is of interest to individuals planning their careers, it should not be interpreted as a complete picture of potential career outcomes.

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Educational decisions, such as the age at receipt of degree and degree field, were associated with unemployment. Obtaining a Ph.D. at a relatively young age was associated with low unemployment. Although there were differences among degree fields, the association between degree field and unemployment was not very strong. Further, the fields that had above or below average rates in 1973 were different from those in 1993.

Interruptions in a full-time career subsequent to receipt of a doctorate are associated with above average unemployment rates. Employment sector, occupation, and geographic location also influenced the probability of current unemployment. The impact of sector and place of employment/residence on unemployment appears to remain stable over time.

It is important to note that unemployment is only one possible career outcome (see box, Unemployment in the Larger Career Context). Other indicators of labor market stress available from the 1993 SDR include the involuntary part-time employment rate and the involuntary out-of-field rate. Groups within the doctoral population with relatively high unemployment rates also tend to have high rates of involuntary part-time employment and involuntary out-of-field employment, though the associations are weak.

Future Research

Additional analytical work suggested by this study includes the following:

- Future work on the correlates of unemployment should ideally include additional variables. Variables found to be related to unemployment in the 1972 NSF study, but not included in the 1993 SDR, were previous work activities[35] and whether Federal support was received for prior work.[36] Additional information about doctoral and other degrees (for example, information about the institutions granting the degrees) and the length of time to complete degrees, information on work history and work skills, and postdoctoral training/employment should also be incorporated. The 1995 SDR that recently became available for analysis contains several interesting new variables that could be used.

- Parallel analyses could be conducted for other aspects of doctoral careers, such as salary level, voluntary and involuntary part-time employment, voluntary and involuntary employment outside degree field, and employment in unsuitable positions. These parallel analyses would place Ph.D. unemployment issues in a broader context.

[35] NSF 1972, p. 22 and 71.
[36] NSF 1972, pp. 24 and 40.

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APPENDIX A

UNEMPLOYMENT, INVOLUNTARY PART-TIME EMPLOYMENT, AND INVOLUNTARY OUT-OF-FIELD RATES, FOR SELECTED SUBGROUPS WITHIN THE DOCTORAL SCIENCE AND ENGINEERING POPULATION: 1993

The following table presents information on the unemployment, involuntary part-time employment, and involuntary out-of-field rates for all of the independent variables considered in this report, plus a limited number of additional variables.

Table A-1. Unemployment, involuntary part-time employment, and involuntary out-of-field rates, for selected subgroups within the doctoral science and engineering population: 1993

Independent Variables	Unemployment Rate	Involuntary Part-Time Rate	Involuntary Out-of-Field Rate	Total Unemployment, Involuntary Part-time, and Out-of-Field
	by Percent			
All Fields	1.6	1.2	3.0	5.9
Natural Sciences and Mathematics	1.7	1.0 L	3.4 H	6.1 H
Agricultural sciences	1.9	0.1 L	3.0	5.0
Biological sciences	1.4	0.9 L	2.5 L	4.8 L
Chemistry	1.8	0.9 L	3.8 H	6.5
Geological and environmental sciences	2.5 H	2.3 H	3.7	8.4 H
Mathematical and computer sciences	1.1 L	1.1	2.4	4.6 L
Physics and astronomy	2.3 H	1.1	6.9 H	10.3 H
Social Sciences	1.4	1.8 H	2.5 L	5.7
Economics	1.4	1.0	0.6 L	3.1 L
Political science	2.0	0.8	3.8	6.5
Psychology	1.3 L	1.9 H	1.6 L	4.8 L
Sociology/Anthropology	1.6	2.5 H	5.1 H	9.2 H
Other	1.5	2.6 H	4.9 H	8.9 H
Engineering	1.7	1.1	2.5 L	5.2 L
Chemical engineering	1.8	0.9	1.3 L	4.0 L
Civil engineering	0.6 L	0.5 L	0.4 L	1.5 L
Electrical engineering	1.9	1.1	3.1	6.1
Mechanical engineering	1.0	1.8	3.1	5.9
Other	2.1	0.9	2.8	5.9

See explanatory information, if any, and SOURCE at the end of table.

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Table A-1 Unemployment, involuntary part-time employment, and involuntary out-of-field rates, for selected subgroups within the doctoral science and engineering population: 1993

Independent Variables	Unemployment Rate	Involuntary Part-Time Rate	Involuntary Out-of-Field Rate	Total Unemployment, Involuntary Part-time, and Out-of-Field
	by Percent			
Place of employment or residence				
Connecticut	1.2	1.5	2.5	5.2
Massachusetts	1.4	1.1	2.6	5.1
Other New England Region	1.5	0.6	2.8	4.9
New York	1.2 L	1.7 H	3.2	6.2
New Jersey	1.3	1.6	3.9	6.8
Pennsylvania	1.6	1.0	2.5	5.1
Ohio	2.2	0.7 L	2.9	5.7
Indiana	1.0	0.6 L	1.8 L	3.3 L
Illinois	1.2	1.2	2.7	5.0
Michigan	1.3	1.2	2.6	5.2
Wisconsin	0.5 L	1.0	3.0	4.5
Minnesota	1.8	1.1	3.5	6.4
Missouri	0.7 L	1.0	2.6	4.3
Other West North Central Region	0.3 L	0.5 L	2.9	3.7 L
District of Columbia	0.7 L	0.5 L	3.3	4.5 L
Florida	2.4	2.0	2.5	6.9
Maryland	2.0	0.7 L	3.3	5.9
North Carolina	1.6	0.7	2.1	4.5 L
Virginia	0.9 L	1.3	3.5	5.6
Other South Atlantic Region	0.6 L	0.4 L	2.2 L	3.2 L
East South Central Region	1.1 L	0.5 L	1.9 L	3.5 L
Texas	2.0	1.2	4.0 H	7.2 H
Other West South Central Region	1.3	0.8	1.5 L	3.6 L
Mountain Region	2.6 H	1.5	2.3 L	6.4
California	2.8 H	2.1 H	3.7 H	8.6 H
Washington	1.9	1.2	4.1	7.3
Other Pacific	1.1	1.5	4.5	7.0
Other	1.1	1.0	2.4	4.5
Years since receipt of Ph.D.				
Less than 1	3.0 H	4.5 H	2.4	9.9 H
1-1.9	1.7	2.2 H	2.1 L	6.0
2-2.9	1.6	1.4	1.3 L	4.3 L
3-3.9	1.3	1.2	2.0 L	4.5 L
4-4.9	1.7	1.0	1.7 L	4.4 L
5-14.9	1.4 L	1.2	2.9	5.5 L
15-24.9	1.5	1.2	4.2 H	6.9 H
25+	2.2 H	0.8 L	2.1 L	5.1 L

See explanatory information, if any, and SOURCE at the end of table.

Table A-1. Unemployment, involuntary part-time employment, and involuntary out-of-field rates, for selected subgroups within the doctoral science and engineering population: 1993

Independent Variables	Unemployment Rate	Involuntary Part-Time Rate	Involuntary Out-of-Field Rate	Total Unemployment, Involuntary Part-time, and Out-of-Field
	by Percent			
Age when doctorate received				
less than 26	1.2	1.0	4.0	6.2
26-27	0.8 L	0.8 L	2.6 L	4.2 L
28-29	1.2 L	0.8 L	3.2	5.3 L
30-31	1.4	0.9 L	2.9	5.1 L
32-33	1.8	1.2	3.2	6.2
34-35	2.0	1.7 H	2.4 L	6.2
36-37	2.2	2.5 H	3.5	8.2 H
38-39	2.6 H	1.8	3.4	7.8 H
40+	3.7 H	2.6 H	2.9	9.2 H
Part-time experience				
0	1.4 L	0.3 L	3.0	4.7 L
1-1.9	2.2	4.6 H	3.3	10.1 H
2-4.9	2.1 H	3.1 H	3.0	8.1 H
5-14.9	2.4 H	3.2 H	3.0	8.6 H
15+	2.0	3.9 H	1.6 L	7.4
Full-time experience				
Less than 5	2.6 H	3.1 H	2.9	8.5 H
5-14.9	1.5	1.3	3.3 H	6.1
15-24.9	1.3 L	1.0 L	3.4 H	5.7
25+	1.8	0.6 L	2.2 L	4.6 L
Employed in 1988?				
No	4.1 H	2.6 H	3.8 H	10.5 H
Yes	1.5 L	1.2 L	2.9 L	5.6 L
Not employed in 1988 and:				
Post-1988 doctorate	1.6	2.1 H	2.2 L	5.9
Pre-1988 doctorate	9.6 H	3.9 H	7.6 H	21.1 H
Occupation in 1988				
Total postsecondary teachers	0.7 L	1.0 L	0.8 L	2.5 L
Postsecondary teachers: math/computer	0.6 L	0.9	1.5 L	2.9 L
Postsecondary teachers: life sciences	0.5 L	0.4 L	0.8 L	1.7 L
Postsecondary teachers: physical sciences	0.4 L	1.7	0.8 L	2.9 L
Postsecondary teachers: social sciences	1.0 L	1.4	0.6 L	3.1 L
Postsecondary teachers: engineering	0.4 L	0.5 L	0.5 L	1.4 L
Total scientists and engineers except postsecondary teachers	1.9 H	1.3	2.9	6.1
Mathematical and computer scientists	2.6 H	1.3	9.8 H	13.6 H
Agricultural scientists	1.0	0.1 L	2.5	3.6 L
Biological scientists	1.8	1.1	1.5 L	4.5 L
Chemists	2.9 H	0.3 L	2.7	5.9

See explanatory information, if any, and SOURCE at the end of table.

Table A-1. Unemployment, involuntary part-time employment, and involuntary out-of-field rates, for selected subgroups within the doctoral science and engineering population: 1993

Independent Variables	Unemployment Rate	Involuntary Part-Time Rate	Involuntary Out-of-Field Rate	Total Unemployment, Involuntary Part-time, and Out-of-Field
	by Percent			
Occupation in 1988 (continued)				
Geologists and environmental scientists	1.9	1.3	3.7	6.9
Physicists	2.3	1.1	4.1	7.5 H
Other physical sciences	5.5	0.0 L	2.6	8.1
Psychologists	0.6 L	2.4 H	0.3 L	3.3 L
Other social scientists	1.4	1.3	1.5 L	4.1 L
Electrical engineers	1.8	1.2	6.0 H	9.0 H
Other engineers	2.5 H	1.4	3.4	7.3 H
Non-scientists and engineers	1.3 L	0.7 L	3.3 H	5.3 L
Managerial and professional2	1.3 L	0.7 L	3.3	5.3 L
Other non-scientists and engineers2	2.1	2.0 H	9.1 H	13.2 H
Employment sector in 1988				
Medical school	0.6 L	0.6 L	1.8 L	3.1 L
University-affiliated research institute	1.6	1.4	2.0 L	5.0
Other four-year college/university	1.1 L	1.1	1.1 L	3.3 L
Other educational employer	1.2	1.6	3.3	6.0
Private for profit employer	2.6 H	1.1	5.5 H	9.2 H
Self-employed -- incorporated	1.2	2.2	5.7 H	9.1 H
Self-employed -- not incorporated	1.0 L	3.2 H	3.9	8.1 H
Private not for profit employer	1.4	1.2	2.1 L	4.7 L
State government	0.8 L	0.5 L	5.8 H	7.1
U.S. Government -- civilian position	1.0 L	0.4 L	3.6	5.0
Other government	2.1	0.5 L	3.1	5.7
Disability status				
Disability related to seeing	1.9	1.3	3.5	6.7
Disability related to hearing	3.0 H	1.4	3.4	7.8 H
Disability related to walking	3.4	2.0	2.6	8.0
Disability related to lifting	3.6 H	2.7	4.3	10.6 H
Marital status				
Married	1.4 L	1.1 L	2.9 L	5.4 L
Not married	2.4 H	1.7 H	3.6 H	7.7 H
Interactions between gender and marital status				
Married men	1.3 L	0.9 L	2.9 L	5.1 L
Unmarried men	2.8 H	1.4	4.0 H	8.1 H
Married women	1.9	2.4 H	2.8	7.1 H
Unmarried women	1.6	2.4 H	2.8	6.8 H

See explanatory information, if any, and SOURCE at the end of table.

Table A-1. Unemployment, involuntary part-time employment, and involuntary out-of-field rates, for selected subgroups within the doctoral science and engineering population: 1993

Independent Variables	Unemployment Rate	Involuntary Part-Time Rate	Involuntary Out-of-Field Rate	Total Unemployment, Involuntary Part-time, and Out-of-Field
	by Percent			
Interactions between gender and whether children in home				
Men with no children in the home	2.1 H	1.1	3.0	6.2
Men with children in the home	1.2 L	0.8 L	3.1	5.1 L
Women with no children in the home	1.2 L	2.4 H	3.0	6.7 H
Women with children in the home	2.4 H	2.3 H	2.6	7.3 H
Interactions between gender and race/ethnicity				
Non-Hispanic white men	1.6	0.9 L	3.0	5.4 L
Non-Hispanic black men	1.2	1.5	1.6 L	4.3 L
Hispanic men	2.0	2.0	2.5	6.5
Asian men	1.7	1.1	4.0 H	6.7 H
Non-Hispanic white women	1.6	2.4 H	2.8	6.9 H
Non-Hispanic black women	1.6	1.2	1.5 L	4.3
Hispanic women	1.6	1.9	0.2 L	3.8 L
Asian women	3.1 H	2.5 H	4.3 H	10.0 H
Interactions between marital status and race/ethnicity				
Married non-Hispanic whites	1.4 L	1.1 L	2.7 L	5.2 L
Unmarried non-Hispanic whites	2.4 H	1.7 H	3.6 H	7.7 H
Married non-Hispanic blacks	0.9 L	1.0	1.7 L	3.7 L
Unmarried non-Hispanic blacks	2.1	2.1	1.4 L	5.6
Married Asians	1.9	1.3	3.9 H	7.1 H
Unmarried Asians	1.7	1.6	4.7 H	8.1 H
Married Hispanics	1.8	2.3 H	1.9 L	6.0
Unmarried Hispanics	2.3	0.8	2.3	5.4
Age				
under 30	1.6	0.3 L	1.7 L	3.6 L
30-34	1.0 L	1.0	1.5 L	3.5 L
35-44	1.3 L	1.2	2.6 L	5.2 L
45-54	1.6	1.4	4.1 H	7.0 H
55-64	2.2 H	1.3	2.7	6.2
65+	4.2 H	1.0	2.0 L	7.3 H
Interactions between birth place and race/ethnicity				
U.S. non-Hispanic white	1.5 L	1.2 L	2.9	5.6 L
U.S. non-Hispanic black	1.2	0.9	1.5 L	3.6 L
U.S. Asian	1.8	1.2	3.1	6.2
U.S. Hispanic	2.4	2.2 H	1.3 L	5.9
Non-U.S. non-Hispanic white	2.1	1.7 H	2.6	6.5
Non-U.S. non-Hispanic black	1.8	2.5	1.7	6.0
Non-U.S. Asian	1.9	1.3	4.1 H	7.3 H
Non-U.S. Hispanic	1.2	1.6	2.9	5.7

See explanatory information, if any, and SOURCE at the end of table.

Table A-1 Unemployment, involuntary part-time employment, and involuntary out-of-field rates, for selected subgroups within the doctoral science and engineering population: 1993

Independent Variables	Unemployment Rate	Involuntary Part-Time Rate	Involuntary Out-of-Field Rate	Total Unemployment, Involuntary Part-time, and Out-of-Field
	by Percent			
Sex				
Men	1.6	1.0 [L]	3.0	5.6 [L]
Women	1.8	2.4 [H]	2.8	7.0 [H]
Race/ethnicity				
Non-Hispanic white	1.6	1.2	2.9 [L]	5.7 [L]
Non-Hispanic black	1.4	1.4	1.6 [L]	4.3 [L]
Asian	1.9	1.3	4.0 [H]	7.2 [H]
Native American	3.1	0.4	2.7	6.3
Hispanic	1.9	2.0 [H]	2.0 [L]	5.8
Interactions between gender and spouse's work status				
Male with full-time working spouse	1.4 [L]	1.2 [L]	3.3 [H]	5.8 [L]
Male with part-time working spouse	1.0 [L]	0.8 [L]	3.0 [L]	4.7 [L]
Male with spouse not working	1.5 [L]	0.5 [L]	2.3 [L]	4.3 [L]
Female with full-time working spouse	2.0 [H]	2.3 [H]	2.9 [L]	7.2 [H]
Female with part-time working spouse	0.5 [L]	3.1 [H]	2.8 [L]	6.5 [H]
Female with spouse not working	1.4 [L]	2.6 [H]	3.9 [H]	7.9 [H]
Parents' education				
Less than high school	1.5 [L]	1.5 [H]	3.1 [H]	6.1 [H]
High school	2.1 [H]	0.9 [L]	3.1 [H]	6.1 [H]
Some college	1.3 [L]	1.2 [L]	3.4 [H]	5.9 [H]
2-year college	1.4 [L]	1.5 [H]	2.4 [L]	5.3 [L]
4-year college	1.3 [L]	1.2 [L]	2.8 [L]	5.4 [L]
Some graduate school	1.2 [L]	1.6 [H]	2.8 [L]	5.6 [L]
Master's	1.6 [L]	1.4 [H]	3.1 [H]	6.2 [H]
Doctorate	1.6 [H]	1.2 [L]	2.8 [L]	5.7 [L]

[H] Significantly higher than average (.05 level)

[L] Significantly lower than average (.05 level)

[2] See the Technical Notes for an explanation of occupations included in this category.

SOURCE: National Science Foundation/SRS, 1993 Survey of Doctorate Recipients.

APPENDIX B

Additional Information on Factors Affecting Unemployment

Introduction

This appendix contains information on a number of variables examined in the process of preparing this report, but judged to be of less interest to readers than the variables presented. These variables are included in this appendix for those with a more specialized interest in this topic, especially researchers interested in performing additional analyses of unemployment.

For ease of presentation, variables discussed in this Appendix have been classified into three groups:

- those examined during exploratory work that were excluded from the multivariate analysis;
- those included in the preliminary multivariate analyses but eliminated for lack of statistical significance from the final model; and
- those found to be statistically significant during the multivariate analysis, but judged to be of relatively low interest to most readers due to the weakness of their association with unemployment and a lack of prior research suggesting they have a significant association with unemployment.

Variables Excluded from the Multivariate Analysis

Pursuit of Additional Degrees and Courses After Receipt of the Doctorate

At the start of the analysis, the relationship between unemployment and the pursuit of additional formal education after receipt of a doctorate was examined. It was hypothesized that receiving another degree after the first doctorate and/or taking additional courses since the last degree would increase marketability. However, the observed unemployment rate was actually higher for those who pursued additional education subsequent to the doctorate, although only the additional course work data were statistically significant.[37] It is important to note that the 1993 SDR did not ask whether the individual had ever had a postdoctoral appointment. A determination of whether a postdoctoral appointment was associated with higher or lower subsequent unemployment, therefore, was not possible.

Presumably, the relatively high unemployment rate associated with additional training at the doctoral level is attributable to respondents who had trouble finding suitable employment in their degree fields and decided to pursue additional training. If this interpretation is correct, it would not be reasonable to include these education and training variables in a regression model designed to estimate unemployment from a series of independent variables.

The survey also contained a series of questions about work-related training received during the preceding year. For three of these variables—management training, technical training, and general professional training—there is a statistically significant relationship in the expected direction; for example, those who had training are less likely to be unemployed than those who did not receive training. Only the category "Other Work-Related Training" was not associated with unemployment. However, individuals who are employed are more likely to have access to free, work-related training than those without employment. It would, therefore, be incorrect to infer that the association between training courses and unemployment is attributable to the actual training courses causing unemployment. Accordingly, these training variables were also excluded from the analysis.

[37] Statistical significance is a function of the size of the sample as well as the strength of a relationship. Since few individuals receive a degree subsequent to their first doctoral degree, the lack of statistical significance may be attributable to the small sample size rather than to a lack of association between the variables.

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Spouse's Work Status

Spouse's work status may well affect the likelihood of being unemployed. Individuals with spouses who have demanding careers may be constrained in their own career choices. On the other hand, having a spouse who is not employed may exert pressure to accept a suboptimal job. Among married respondents, unemployment was lowest for those who had spouses employed part-time (1.0 percent). Those with spouses employed full-time, or not employed, had unemployment rates of approximately 1.5 percent (table B-1). The pattern was similar for men and women (table A-1).

Among those who had employed spouses, the type of work done by the spouse might constrain the individual's career choices and thus affect the unemployment rate. One question on the 1993 SDR that permitted exploration of this issue was whether the spouse's job required expertise equivalent to a bachelor's degree in one of the following areas: natural science or engineering, social science, or another field. Having a spouse employed in the social sciences (1.0 percent) or in non-B.A. fields (0.8 percent) was associated with slightly lower unemployment rates than was having a spouse employed in the other fields.

Although these interrelationships were statistically significant, the difficulty in interpreting multiple complex interaction effects, such as the simultaneous consideration of the interaction effect of gender and spouse's work status on unemployment and the interaction effect of gender and marital status on unemployment, led to a practical limitation on the number of interaction effects included. The interaction effects between gender and spouse's work status were considered to be of less interest than the interaction effects studied in the analysis. Adding the spouse work status variables to the basic regression model used in this analysis indicated that little explanatory power was lost by deleting these variables.

Professional Association Activities

Professional society membership and attendance at professional society meetings were associated with low unemployment rates (table B-2). Individuals who attended no professional association meetings in the preceding year had an unemployment rate of 4.1 percent, compared to 1.0 percent for those who attended at least one meeting. Those who had no professional association memberships had an unem-

Table B-1. Unemployment rates for doctoral scientists and engineers, by spouse's work status: 1993

Spouse's Work Status	Population Size	Unemployment Rate -- by Percent
Has spouse who is not employed	113,550	1.5
Employed:		
Full time	193,090	1.5
Part time	67,750	1.0 *
Employed:		
Science	87,690	1.6
Social Science	63,890	1.0 *
Other B.A. field	88,600	1.6
No B.A. field	20,650	0.8 *

*Difference between unemployment rate observed in group and total unemployment rate excluding those in the group is statistically significant at .05 level.

' See the Technical Notes for an explanation of the adjustment methodology used in calculating standardized unemployment rates.

NOTE: Detail may not add to total because of rounding.

SOURCE: National Science Foundation/SRS, 1993 Survey of Doctorate Recipients.

Table B-2 Unemployment rates for doctoral scientists and engineers, by professional association activities: 1993

Professional Association Activities	Population Size	Unemployment Rate -- by Percent
Attended a professional association meeting within the last year		
No	95,220	4.1 *
Yes	375,250	1.0 *
Number of national professional association memberships		
0	58,000	3.7 *
1	94,790	1.9
2	111,980	1.4 *
3	85,390	1.1 *
4	49,590	1.2 *
5	32,540	0.6 *
6	17,560	1.0 *
7	5,610	1.1
8	5,600	0.7 *
9 or more	9,410	0.6 *
All individuals**	470,500	1.6

* Difference between unemployment rate observed in group and total unemployment rate excluding those in the group is statistically significant at .05 level.

** Includes individuals for whom information on professional associations was not available.

'See the Technical Notes for an explanation of the adjustment methodology used in calculating standardized unemployment rates.

NOTE: Detail may not add to total because of rounding.

SOURCE: National Science Foundation/SRS, 1993 Survey of Doctorate Recipients.

ployment rate of 3.7 percent. Rates tended to decline as the number of memberships increased—those with 9 or more memberships had an unemployment rate of 0.6 percent. However, it seems reasonable to hypothesize that this association is at least partially attributable to employer contributions to, and encouragement of, professional society activities. Therefore, these two variables were excluded from the multivariate analysis.

Other Variables

The 1993 SDR includes a number of variables related to the reasons for taking certain actions, such as obtaining training. These were ultimately not included, because it seemed likely that associations between these variables and unemployment are indicative of actions individuals took in response to their employment situation, rather than factors that affect the likelihood of being unemployed. It would, therefore, be misleading to include them in a model designed to identify factors leading to unemployment.

Variables Eliminated During the Multivariate Analysis for Lack of Statistical Significance

Occupational Characteristics

Broad occupational groups were used in the primary analysis of occupation in the doctoral science and engineering population. However, within each of these groups, subfields may have had different unemployment rates. Small sample sizes for these subfields precluded reasonably reliable estimates of subfield unemployment rates. Characteristics of detailed 1988

occupations associated with unemployment status in 1993 were examined. The characteristics of the detailed occupations were derived from the SRS/NSF 1993 National Survey of College Graduates (NSCG), a survey of individuals who reported having bachelor's or higher degrees in the 1990 Census.

Two of the three variables examined did not have a statistically significant association with unemployment after controlling for the other variables in the preliminary multivariate analyses and were, therefore, deleted from the final model. These variables were the salary level of the 1988 occupation and the percent of those in the NSCG survey employed in the 1988 occupation who had a doctoral degree. For both of these variables, individuals employed in the lower-ranked (i.e., lower salary or lower percentage of doctoral individuals) occupations in 1988 were more likely to be unemployed in April 1993. Although these relationships were not statistically significant when examined in the logistic regression equation, the direction of the relationship is consistent with the general observation of this report that indicators of previous interruptions in suitable full-time work were associated with more unemployment in 1993.

Prior Retirement

As expected, previous retirement negatively affected current employment. The unemployment rate was 3.4 percent among those who had previously retired, compared to 1.5 percent for those who had not previously retired. However, when previous retirement was included in the multivariate analysis, it was not statistically significant. Thus, the observed relationship between previous retirement and unemployment appears to be explained by the control variables.

Birth in a Rural Area

There is little difference in the unemployment rates of individuals who lived in rural areas while growing up and those who did not. Both groups had unstandardized unemployment rates of approximately 1.6 percent. After controlling for the other variables, the regression analysis did not show statistically significant differences between these two categories.

Citizenship

Because many government and government-contractor jobs require U.S. citizenship and because employment is a prerequisite for certain types of visas, it is not surprising that permanent residents had a higher unemployment rate (2.2 percent) than temporary residents (1.4 percent) or U.S. citizens (1.6 percent) in 1993.

The relative advantage of being a U.S. citizen was also observed in the 1972 NSF report. In 1971, the unemployment rate was 2.5 percent for U.S. citizen scientists (compared with 4.2 percent for non-U.S. citizens) and 3.0 percent for U.S. citizen engineers (compared to 4.6 percent for non-citizens). However, controlling for other variables reduced the observed association between citizenship status and unemployment, causing them to be statistically non-significant.

Interaction Between Race/Ethnicity and Whether Born in the United States

Prior work on salary differentials by race/ethnicity indicated that it is helpful to examine separately salary levels by race/ethnicity, for individuals born in the United States and those born in other countries.[38] Therefore, after race/ethnicity was deleted from the analysis, the possibility of the interaction effect between race/ethnicity and whether the person was born in this country was examined. The relationship was not statistically significant (though these data included only those who received their doctorates from U.S. institutions).

Other Variables in the Final Model Not Discussed in the Body of the Report

1988 Occupation Characteristics

Certain characteristics of the 1988 detailed occupational fields were examined to determine whether or not they contributed to the explanation of unemployment in 1993. Only one characteristic was

[38] NSF 96-311.

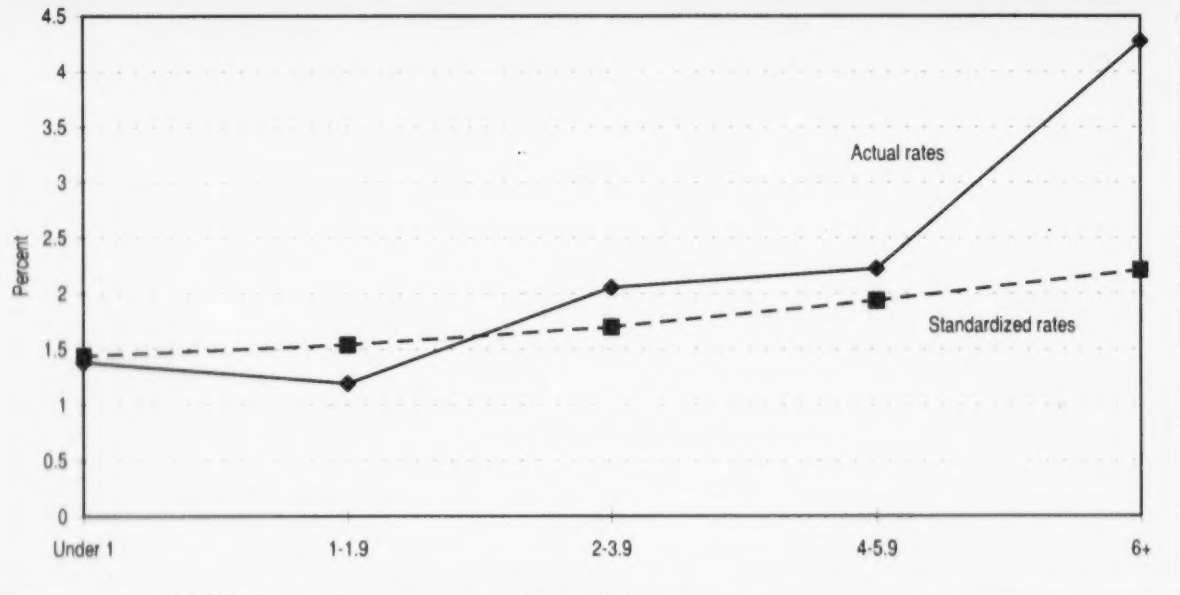
statistically significant—the percent of college-educated individuals in the detailed occupation reported in the 1993 NSCG as employed involuntarily out-of-field.[39] Those employed in occupations that had involuntarily out-of-field rates exceeding 6 percent had a 4.3–percent unemployment rate, compared to an unemployment rate of only 1.2 percent for those in occupations having 1 to 2 percent involuntarily out-of-field rates (chart B-1).

The impact of this variable, however, was significantly diminished by the controls. Standardized unemployment rates ranged from 1.4 percent for those in 1988 occupations characterized by a 0.5–percent involuntary out-of-field rate to 2.2 percent for those in occupations characterized by a 7.0–percent involuntary out-of-field rate. Because of the difficulty in explaining this relatively complex measure and the small impact, this variable was not discussed in the body of the report.

Parental Education

Family background is likely to influence the probability of unemployment. Therefore, it is conceivable that parents' educational level has an effect on the likelihood of being unemployed. Although the analysis confirmed a statistically significant relationship between parental education and unemployment, the nature of this relationship is weak and difficult to describe (table B-3). Individuals whose parents had less than a high

Chart B-1. Unemployment rates of persons with doctoral degrees in science and engineering, by percent of those in 1988 occupation who were involuntarily out-of-field: 1993



NOTE: See the Technical Notes for an explanation of the adjustment methodology used in calculating standardized unemployment rates.

SOURCE: National Science Foundation/SRS, 1993 Survey of Doctorate Recipients.

[39] The occupation characteristics were based on information obtained from the 1993 National Survey of College Graduates. See the Technical Notes for additional information.

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Table B-3. Unemployment rates for doctoral scientists and engineers, by parental education: 1993

Parental Education	Population Size	Actual Unemployment Rate	Standardized Unemployment Rate[1]
		by Percent	
Less than high school	55,200	2.3 *	1.9
High school	107,200	1.5	1.6
Some college	65,260	2.1 *	2.1
2-year college	18,270	1.3	1.2
4-year college	87,330	1.4	1.5
Some graduate school	20,280	1.3	1.4
Master's	53,650	1.2 *	1.3
Doctorate	62,500	1.6	1.7
All individuals**	471,000	1.6	1.6

* Difference between unemployment rate observed in group and total unemployment rate excluding those in the group is statistically significant at .05 level.

** Includes individuals who did not know parents' educational level.

[1]See the Technical Notes for an explanation of the adjustment methodology used in calculating standardized unemployment rates.

NOTE: Parental education is defined as the education level of the more highly educated parent. Detail may not add to total because of rounding.

SOURCE: National Science Foundation/SRS, 1993 Survey of Doctorate Recipients.

school education or some college had unemployment rates above 2 percent, compared to the 1.2 to 1.6 percent rates for those in the other categories.

Interaction Between Marital Status and Race/Ethnicity

Although race/ethnicity did not have a statistically significant association with unemployment, there was an association between race/ethnicity, marital status, and unemployment (table B-4). Unemployment rates indicate that for non-Hispanic whites, Hispanics, and non-Hispanic blacks, unemployment rates are higher for unmarried individuals than for married individuals. However, there was little difference in the rates for married and unmarried Asians.

Foreign Research Experience

Experience conducting research outside of the United States, or interest in this experience, is another work-related variable that could affect employability. Although this variable was statistically significant in the multivariate analysis, its impact was minor.

Table B-4. Unemployment rates for doctoral scientists and engineers, by marital status and race: 1993

Marital Status/Race	Population Size	Actual Unemployment Rate	Standardized Unemployment Rate[1]
		by Percent	
Married -- total**	374,390	1.4 *	1.4
Non-Hispanic white	313,690	1.4 *	1.4
Non-Hispanic black	6,380	0.9 *	0.9
Asian	45,550	1.9	1.5
Hispanic	7,390	1.8	1.8
Not married -- total**	96,110	2.4 *	2.4
Non-Hispanic white	83,010	2.4 *	2.4
Non-Hispanic black	3,380	2.1	2.4
Asian	7,120	1.7	1.3
Hispanic	2,210	2.3	2.4
All individuals**	470,500	1.6	1.6

* Difference between unemployment rate observed in group and total unemployment rate excluding those in the group is statistically significant at .05 level.

** Includes Native Americans who are not shown because of small cell sizes.

[1]See the Technical Notes for an explanation of the adjustment methodology used in calculating standardized unemployment rates.

NOTE: Detail may not add to total because of rounding.

SOURCE: National Science Foundation/SRS, 1993 Survey of Doctorate Recipients.

APPENDIX C:
TECHNICAL NOTES

Data Used in This Report

The Survey of Doctorate Recipients

The 1993 Survey of Doctorate Recipients (SDR) includes individuals under 76 years of age who received a research doctorate in science or engineering from a U.S. university in 1992 or earlier. The focus of the current report was restricted to individuals in the labor market[40] at the time of the survey (April 1993). Thus, individuals who were neither employed nor seeking employment at that time were excluded from the analyses. The available sample size was approximately 36,000 cases.

Historical Data

Changes have been made in the population definition and data collection procedures for the SDR that reduce the direct comparability of the earlier surveys with the 1993 survey.[41] The 1973 data were adjusted to make them as comparable as possible to the 1993 data.[42]

A report by the National Science Foundation (NSF), *Unemployment Rates and Employment Characteristics for Scientists and Engineers, 1971,* is used for comparison purposes within this report, even though the NSF study differed considerably in population definition and research design from the 1993 SDR. The scientists for the earlier NSF survey were those included in the 1970 National Register of Scientific and Technical Personnel. To be included in the register, individuals were required to have "full professional standing based on academic training and work experience, as determined by the appropriate scientific professional society for the fields of science covered."[43] Approximately 60 percent of the scientists did not have doctorates.[44] Engineers were selected from a mailing list maintained by the Engineers Joint Council that "consisted of 23 major engineering societies and constituted about 40 percent of the total number of individuals in the Nation identified as engineers."[45] Thus, the definitions of scientist and engineer in the 1972 study were not strictly comparable to one another, nor were they comparable to the 1993 definition of an individual with a doctorate in one of the science and engineering fields.

Total Population Data

Information on total population unemployment was taken from data collected by the Bureau of Labor Statistics (BLS) in the Current Population Survey (CPS). The definition of unemployment used in the CPS is essentially the same as that used in the SDR.

Trend Analysis

Changes in the SDR methodology over time (e.g., fluctuating response rates and population definitions) have affected the size of the unemployment rate estimates. In 1973, the response rate for the survey was 75 percent. Between 1973 and 1989, the response rate gradually declined to 55 percent. In 1991, extensive locating and telephone follow-up procedures were instituted that helped raise the response rate in 1991 and 1993 to approximately 87 percent. During the 1991 redesign of the SDR, the population definition was modified. The 1973 study used a sample frame that included many individuals who received doctoral degrees from non-U.S. institutions. However, after 1973, only individuals with doctoral degrees from U.S. institutions were added to the survey. By 1991, it was clear that the coverage of the non-U.S.-educated population was extremely poor. Since improving this coverage within the SDR was not practical, this segment was deleted entirely.

To understand the likely impact of the 1991 changes on the unemployment rate, rates were calculated for 1989 and 1991 using population and methodological definitions that were as similar as possible. Foreign-educated individuals were excluded from the 1989 estimate, and individuals who responded during

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[40] An individual in the labor market is defined as employed or, if not employed, having actively sought work within the preceding four months or being on layoff.

[41] See the Technical Notes for a discussion of changes in the SDR over time.

[42] See below (under Trend Analysis) for more information on this adjustment.

[43] NSF 1972, pp. 112–113.

[44] NSF 1972, p. 15.

[45] NSF 1972, pp. 114–115.

the telephone follow-up stage in 1991 were also excluded from this comparison. The resulting unemployment rate for the 1989 group was 0.8 percent; the 1991 rate was 1.3 percent. The published rates with the differing population definitions and methodology for the two years were 0.8 percent and 1.4 percent. Therefore, it appears that the changes in methodology and population definition resulted in a slight increase in the estimated unemployment rate between the two years. Since the impact of the changed methodology on unemployment rates did not appear to be substantial, it was decided that a fairly good approximation for trend analysis purposes could be made by adding 0.1 percent to the pre-1991 unemployment rates.

There are some discrepancies in reported doctoral unemployment rates for 1973. The rate reported in the National Academy of Sciences publications was 1.2 percent, although the 1973 rate reported in the NSF's *Characteristics of Doctoral Scientists and Engineers in the United States: 1989* was 1.1 percent. Since the latter rate was published as part of the trend analysis used to calculate the adjusted 1989 rate, it was assumed that the NSF rate was the best rate for use in calculating adjusted pre-1989 figures.

Variable Definitions

Unemployment Rate

The definition of unemployment used in this report is the standard Federal definition of the percent of individuals in the labor force who were not employed. The labor force is defined as individuals who were employed, were on lay-off, or had sought work within the preceding four weeks. Although this is the most commonly used measure of unemployment, other measures are used. The Bureau of Labor Statistics, for example, in a 1995 article discusses a variety of alternative measures used for different purposes (Bregger and Haugen).

Involuntary Part-Time Rate

The involuntary part-time rate is defined as the number of individuals who reported working part-time exclusively because suitable full-time work was not available, divided by the number of individuals in the labor force.

Involuntary Out-of-Field Rate

For this report, the involuntary out-of-field rate is defined as the number of individuals (other than those who were involuntarily part-time employed) who reported that they were working out of their doctoral field at least partially because suitable work in the field was not available, divided by the number of individuals in the labor force. This is slightly different than the definition used in the NSF report, *Characteristics of Doctoral Scientists and Engineers in the United States: 1993,* which combines individuals who are involuntarily part-time or involuntarily out-of-field into a single measure, referred to as involuntary out-of-field. For the purposes of this report, the components are broken out. This report also uses the number of individuals in the labor force as the denominator for calculating this rate, rather than the number of employed individuals, in order to facilitate combining the three measures of adverse career events.

Occupation

Standard SRS occupational groupings were used for coding the 1988 science and engineering occupations. These codes are detailed in NSF 96-302. For non-science and engineering occupations, a further breakdown of occupations into managerial or professional specialty positions was made. Non-management/professional specialty occupations included: technologists and technicians; clerical/administrative support; computer programmers; surveyors; farmers, foresters, and fishermen; nurses; sales and marketing; service occupations other than health; and elementary and secondary teachers. Jobs in this category were selected based on the characteristics of individuals in these jobs in the 1993 National Survey of College Graduates. The remaining non-S&E occupations were considered to be managerial and professional specialty jobs. This category includes the clergy, lawyers, and managers, where high-level degrees are common.

Variables Related to 1988 Employment and Occupational Status

The 1993 SDR included a series of questions about the employment status of individuals in 1988. These questions asked whether the individual had

changed employer or occupation since 1988 and, if so, asked for information about the 1988 position. This retrospective information was used throughout the report to describe 1988 occupational characteristics.

Other Variables

In examining associations between single variables and the unemployment rate, the goal was to restrict analyses to groups that consisted of at least 400 sample cases. This is a relatively large cut-off, because of the high sampling variability encountered in small samples when rates are as low as 1.6 percent. Meeting the minimum sample size goal required collapsing categories. When logical combinations did not permit the desired sample size goal to be met, smaller sample sizes were retained. If this was not feasible, small residual categories were treated as missing for the purposes of examining the bivariate relationships between the independent variables of interest and unemployment status.

The categories used in the bivariate analyses were also used as a starting point for creating dummy variables for the multivariate work. However, since the regression routines used in the multivariate analyses ignore all cases with missing values for one or more variables, the missing value codes were examined again before conducting the multivariate analysis. Some categories (for example, "Other Physical Science" under degree field) that were not displayed in the univariate analysis were used in the multivariate analysis. The remaining missing value cases were treated as if they belonged to whichever dummy variable category had been selected for omission in the dummy variable regression. Normally, this was the modal category for the variable.

Standard Errors and Tests of Significance

Observed differences in comparing unstandardized unemployment rates between groups were tested for statistical significance at the .05 significance level. Standard errors for these tests were calculated using the equation appropriate for a simple random sample. This is equivalent to assuming that there is no design effect. Although this methodology provides only an approximate estimate of the standard error, it greatly simplifies computation. Since the sample design for the survey was a stratified random sample, this approach should provide reasonably good estimates.

Sample sizes for some of the 1973 subgroups used in comparing 1973 and 1993 unemployment rates were not readily available. Therefore, the number of cases in the subgroup was estimated by multiplying the 1993 sample size for the group by the ratio of total 1973 sample size to total 1993 sample size. Although this is a fairly rough test, it provides general guidance on the probable statistical significance of observed differences.

Standardization Methodology

The first step in developing a model for estimating unemployment was an examination of the bivariate associations between the independent variables of interest and unemployment. Some variables were eliminated from further consideration after examination of these relationships based primarily on whether the observed bivariate relationship could reasonably be interpreted as one in which the independent variable affected unemployment. For example, non-work-related training appeared to be associated with high unemployment rates. However, it seems more reasonable to believe that being unemployed leads one to seek additional training than that obtaining additional training increases the probability of unemployment. The bivariate relationships for these omitted variables were discussed in Appendix B.

The preliminary analysis also suggested the appropriate shape of curves to fit in the multivariate analysis. For example, for variables (such as years since the doctorate was earned) that display high unemployment rates at the extremes of the distribution, parabolic relationships were fit by including squared and linear terms for the relevant independent variables.

Once the preliminary independent variables were identified, a multiple regression analysis was performed to identify possible problems with multicollinearity that required the deletion of additional variables.[46] Stepwise regression analysis was also used to determine if there were additional variables that could be deleted due to a lack of statistical significance. Variables omitted at this

[46] All analyses for this report were performed using SAS.

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stage included gender, race/ethnicity, and whether the individual had children. At that point, a limited number of plausible two-way interactions were introduced into the analysis and tested for statistical significance (for example, gender by whether children are present). The next step was to perform a logistic regression analysis. The preliminary logistic model was simplified by eliminating variables that were not statistically significant from the model.[47] The parameters for the final logistic regression model are presented in table C-1.

A problem with using logistic regression analysis is that interpretation of the results is not straightforward. The impact of an independent variable on unemployment depends on the value of the other variables in the model. Since such complex relationships are difficult to comprehend, a standardization technique was used. For most variables, iterative techniques were used to select a standardization value for all factors other than the independent variable of interest. This resulted in a total unemployment rate equal to the observed unemployment rate.

The standardization methodology selected was modified slightly to deal with situations where there was a logical dependence between categoric independent variables in the analysis. For example, individuals categorized as not employed in 1988 in the occupational analysis were categorized the same way in the sector variable. Logit regression parameters were calculated for each category formed by cross-classifying the interdependent independent variables. For example, chemists in the private sector would have a combined logit parameter equal to the sum of the parameters for the dummy variable for chemists, the value for the dummy variable for the private sector, and the values of the dummy variables used to indicate employment and student status. Standardization was performed for these detailed occupations by sector categories, and the value for each sector and occupation was obtained by weighting these subcategories—for example, sector categories within an occupation group—according to the observed distribution.

An exception to this general treatment was made for the variable characterizing 1988 occupation by the percent of individuals within the occupation in the 1993 NSCG who were involuntarily out-of-field (an indicator of the perceived desirability of the occupation). For this variable, the standardized values for the two unemployed in 1988 categories were set equal to the values observed in the analysis of 1988 occupation and 1988 sector described prior to calculating standardized values for the remaining categories.

For continuous variables, standardization was done within categories. For the purpose of evaluating the regression values, the midpoint of the category was used to estimate the dependent variable mean unless knowledge of the data suggested a different value would be more appropriate.

In standardizing for disability status, the categories were not mutually exclusive, because of the possibility that an individual could have multiple disabilities. Instead of standardizing to the total observed unemployment rate or forcing the categories to be mutually exclusive, unemployment rates were standardized to a hypothetical total unemployment rate calculated from the observed values of the univariate disability categories.

[47] Note that interaction effects were tested after a decision was made on whether the primary variables should be retained.

Table C-1 Regression parameters and standard errors for logistic regression model

Independent Variables	Parameters	Standard Error
INTERCEPT	-2.4199	0.5168 *
Place of employment or residence		
Connecticut	-0.6984	0.1086 *
Massachusetts	-0.6324	0.0651 *
Other New England Region	-0.2991	0.1029 *
New York	-0.7088	0.0534 *
New Jersey	-0.8328	0.0687 *
Pennsylvania	-0.4133	0.0615 *
Ohio	-0.0872	0.0602
Indiana	-0.7502	0.1187 *
Illinois	-0.7582	0.0732 *
Michigan	-0.5932	0.0833 *
Wisconsin	-1.3787	0.1645 *
Minnesota	-0.2931	0.0892 *
Missouri	-1.0868	0.1344 *
Other West North Central Region	-1.7205	0.1664 *
District of Columbia	-1.2771	0.112 *
Florida	-0.02	0.0684
Maryland	-0.3117	0.0616 *
North Carolina	-0.2645	0.0779 *
Virginia	-1.0293	0.096 *
Other South Atlantic Region	-1.359	0.1013 *
East South Central Region	-0.7796	0.0771 *
Texas	-0.2405	0.0524 *
Other West South Central Region	-0.4771	0.0873 *
Mountain Region	0.0682	0.0458
{California}**	--	--
Washington	-0.3089	0.0762 *
Other Pacific	-0.8448	0.1054 *
Other	-0.8977	0.2368 *
Years since receipt of Ph.D.		
Years since receipt of Ph.D.	0.0604	0.00492 *
Years since receipt of Ph.D. squared	0.000696	0.000114 *
Field of degree:		
{Biological sciences}**	--	--
Mathematical and computer sciences	-0.2194	0.0757 *
Agricultural sciences	0.5105	0.0721 *
Geological and environmental sciences	0.4827	0.069 *
Chemistry	-0.2337	0.0565 *

See expanatory information, if any, and SOURCE at the end of table.

Table C-1. Regression parameters and standard errors for logistic regression model

Independent Variables	Parameters	Standard Error
Field of degree (continued):		
Physics and astronomy	0.4015	0.0581 *
Other physical sciences	0.00927	0.2615
Economics	0.3063	0.075 *
Political science	0.4099	0.0746 *
Psychology	0.1769	0.0522 *
Sociology/Anthropology	-0.1228	0.0716
Other social sciences	-0.1328	0.0858
Chemical engineering	0.0227	0.0847
Civil engineering	-1.1496	0.1672 *
Electrical engineering	0.1944	0.0719 *
Mechanical engineering	-0.5593	0.1126 *
Other engineering	0.0996	0.0634
Age when doctorate received		
Age at Ph.D.	0.1175	0.00243 *
Part-time experience		
Years part-time experience	0.0642	0.00627 *
Years part-time experience squared	-0.00375	0.000346 *
Full-time experience		
Years full-time experience	-0.0959	0.00434 *
Years full-time experience squared	0.000861	0.0001 *
Employed in 1988?*		
Employed in 1988?	0.3878	0.0818 *
Employed or non-doctorate in 1988?	-1.4275	0.0768 *
Occupation in 1988		
Mathematical and computer scientists	-0.1023	0.0752
Postsecondary teachers: math/computer	-0.9684	0.1227 *
{Biological scientists}**	--	--
Agricultural scientists	-1.1581	0.126 *
Postsecondary teachers: life sciences	-1.2751	0.0972 *
Chemists	0.4554	0.0704 *
Geologists and environmental scientists	-0.5614	0.1009 *
Physicists	-0.2747	0.0826 *
Other physical sciences	0.4223	0.1264 *
Postsecondary teachers: physical sciences	-1.5963	0.1239 *
Psychologists	-1.526	0.0947 *
Other social scientists	-0.6794	0.0983 *
Postsecondary teachers: social sciences	-0.958	0.0779 *
Electrical engineers	-0.6309	0.1019 *

See expanatory information, if any, and SOURCE at the end of table.

Table C-1. Regression parameters and standard errors for logistic regression model

Independent Variables	Parameters	Standard Error
Occupation in 1988 (continued):		
Other engineers	0.0534	0.0653
Postsecondary teachers: engineering	-1.475	0.1485 *
Managerial and professional1	-0.6172	0.0534 *
Other non-scientists and engineers1	-0.7309	0.0699 *
Employment sector in 1988		
Medical school	-0.679	0.0793 *
University-affiliated research institute	0.0251	0.0606
{Other four-year college/university}	--	--
Other educational employer	-0.0813	0.1
Private for profit employer	0.66	0.0391 *
Self-employed -- incorporated	-0.4535	0.1052 *
Self-employed -- not incorporated	-0.6924	0.0832 *
Private not for profit employer	-0.0198	0.0677
State government	-0.5452	0.1285 *
U.S. government -- civilian position	-0.4476	0.071 *
Other government	0.4491	0.0838 *
Parents' education		
Less than high school	0.2103	0.0398 *
{High school}	--	--
Some college	0.2954	0.0385 *
2-year college	-0.2939	0.072 *
4-year college	-0.0681	0.0391
Some graduate school	-0.1282	0.0681
Master's	-0.1779	0.049 *
Doctorate	0.1038	0.0424 *
Disability status		
{Not disabled}	--	--
Disability related to seeing	-0.186	0.0878 *
Disability related to hearing	0.4292	0.0606 *
Disability related to walking	0.3177	0.1161 *
Disability related to lifting	0.2902	0.0965 *
Average percent in 1988 occupation involuntarily out of field****	6.7056	0.747 *
Foreign research experience		
Conducted foreign research	0.2869	0.0433 *
Would consider conducting foreign research	0.3483	0.0304 *
{Neither conducted nor would consider conducting foreign research}**	--	--

See expanatory information, if any, and SOURCE at the end of table.

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Table C-1. Regression parameters and standard errors for logistic regression model

Independent Variables	Parameters	Standard Error
Marital status		
Married	-4.2888	0.5053 *
married	--	--
Interactions between gender and marital status		
Married female	0.4624	0.0703 *
Other	--	--
Interactions between gender and whether children in home		
Women with children in the home	0.8661	0.0575 *
Men with children in the home	-0.0781	0.032 *
No children in the home (total)	--	--
Interactions between gender and race/ethnicity		
Non-Hispanic white women	-0.8512	0.0583 *
Non-Hispanic black women	-0.3166	0.1897
Hispanic women	-1.3319	0.2001 *
Asian women	-0.2604	0.0972 *
Native American (total)***	-1.8798	0.4761 *
Interactions between marital status and race/ethnicity***		
{Married non-Hispanic whites}	--	--
Unmarried non-Hispanic whites	-3.5736	0.5051 *
Married non-Hispanic blacks	-0.6395	0.15 *
Unmarried non-Hispanic blacks	-3.7227	0.5244 *
Married Asians	-0.053	0.0463
Unmarried Asians	-4.311	0.5135 *
Married Hispanics	0.3014	0.0986 *
Unmarried Hispanics	-3.4297	0.5281 *

* Statistically significant at the .05 level.

** {}'s are used to indicate omitted dummy regression variables.

*** Due to the small number of Native Americans in the sample, a single category of Native Americans was used.

**** Unemployed indivduals were given a value equal to the mean of employed indivduals on this variable.

'See the Technical Notes for an explanation of occupations included in this category.

SOURCE: National Science Foundation/SRS, 1993 Survey of Doctorate Recipients.

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